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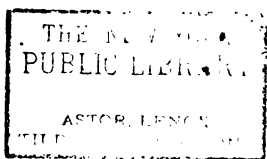
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THE ALCHEMIST.

FROM A PICTURE PAINTED BY TENIERS. (See p. vii.)

Things not generally Known.

CURIOSITIES OF SCIENCE:

Second Series.

A BOOK FOR OLD AND YOUNG.

By JOHN TIMBS, F.S.A.,

AUTHOR OF "THINGS NOT GENERALLY KNOWN;" AND EDITOR OF "THE
YEAR-BOOK OF FACTS."



Decomposition of Water under the Oxyhydrogen Gas Microscope.
(See page vii.)

Third Edition; Fifth Thousand.

LONDON:

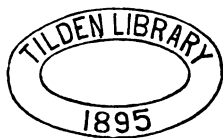
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W. W. W. W. W.
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W. W. W. W. W.

This Second Series of "CURIOSITIES OF SCIENCE" completes the anecdotic illustrations commenced in the First Series : at the same time it forms the Sixth Volume of "THINGS NOT GENERALLY KNOWN FAMILIARLY EXPLAINED," and concludes that design.

The present volume is devoted, in the main, to CHEMISTRY, its Students and Professors. In the plan, the object has not been systematic tuition ; although the sequence of subject has been kept in view, so far as could be appropriately realised. The early portion of the volume is retrospective and historical, illustrating the profession of ALCHEMY in brief biographical notices of its practitioners ; then tracing the transition from Alchemy to Modern Chemistry, and attempting to distinguish the early Chemists from the Alchemists—the real from the ideal—the founders of a great science from the charlatans of low artifice and imposture. In this section of the work an attempt has been made to sketch the fates and fortunes of the Alchemists, briefly and without recourse to the *shibboleth* of their art ; special regard being had for the individual characteristics of the practitioners, their portraitures and habits and true histories.

Under "MODERN CHEMISTRY" and "GENERAL SCIENCE" striking Facts and Phenomena are popularly recorded,—often by way of anecdote,—keeping in view the recreative object of this little volume, which, in accordance with others of the Series of which it forms a portion, seeks to impart information and entertainment in the same moment, respecting "THINGS NOT GENERALLY KNOWN."

In presenting you with this volume, I recur with grateful feelings to the large share of public favour which continues to be extended to the entire Work. Its main idea—that of seizing upon topics imperfectly understood, and conveying, in an attractive form, information beyond commonplace—has been purloined and parodied in a legion of shapes, and often with such disfigurement as gipsies inflict upon stolen children. Nevertheless, the unflagging interest taken by the reading public in the portion of "THINGS NOT GENERALLY KNOWN" already published, leads me to hope that the like favour may be extended to the present volume.

I. T.

June 1860.

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The Frontispiece.

THE ALCHEMIST, PAINTED BY TENIERS.

This aged experimentalist in "the more sublime and occult part of chemistry" is the principal figure in a picture by the younger Teniers, from the Orleans Gallery. It is characteristic of the attention paid to the Alchemists and their labours in the present work; and when it is remembered how much Chemists owe to the Alchemists, the details of their art and mystery may fairly be numbered among the "Curiosities of Science." (See pp. 1-47.)

The Vignette.

DECOMPOSITION OF WATER UNDER THE OXYHYDROGEN GAS MICROSCOPE.

The Decomposition of Water by chemical action presents a very curious appearance under the Gas Microscope: it was exhibited at the Royal Gallery of Practical Science, Strand; at the Polytechnic Institution in Regent Street; and other establishments of this class, which have so long gratified a healthy taste amongst the people for the marvels of modern science. The process is thus described by Mr. Edward M. Clarke, in his *Directions for using Philosophical Apparatus in Private Research and Public Exhibitions*. The Author will be remembered as a manufacturer of Mathematical, Philosophical, and Optical Apparatus, in the Strand. He supplied many of the instruments at the Adelaide Gallery, at the Colosseum in the Regent's Park, and at the Polytechnic Institution; and to Mr. Clarke's untiring industry was mainly due the establishment of the Panopticon in Leicester Square; an enterprise which, unfortunately for the public as well as the proprietors, did not prove commercially successful. It is, however, due to a man of Mr. Clarke's energetic character to state these facts, that the exertions of one who laboured so zealously for the public gratification may be rightly appreciated. In England Scientific Exhibitions are left to the chances of ordinary speculation; and little is done by the State in this great country of the Steam-engine to gratify the desires of the people for scientific study or recreation, unless the scheme be recommended by some prospects of patronage and personal influence. If, however, it were rightly considered how much the scientific colour of public amusements is calculated to benefit the intelligence of the people, more attention would be paid to the subject.

The Decomposition of Water is effected by the adaptation of a gl

trough to the microscope (introduced horizontally in the manner of a slider), containing diluted sulphuric acid, similar to that employed in the preparation of hydrogen gas. On a few pieces of fresh-broken zinc being dropped into the diluted acid, decomposition of the water instantly commences. Its oxygen gas combines unperceived with the zinc, which then dissolves gradually in the sulphuric acid; while the hydrogen gas, set free at the same instant, rapidly rises in bubbles through the liquid, and escapes at the surface. These bubbles, magnified, present a most extraordinary appearance, forming a series of whitish luminous globules, descending in the fluid (for every thing appears reversed in the microscopic exhibitions) from an opaque surface, and swelling enormously as they struggle, under the trebly expansive powers of heat, combination, and lessening pressure.

By means of the glass troughs, made without joinings in moulds, Mr. Clarke was enabled to adapt with fine effect Sturgeon's interesting experiment of the Decomposition of Water by a voltaic circuit arising from the action of Platinum on amalgamated Zinc, in the following manner. The trough, containing diluted sulphuric acid, as in the previous exhibition, is introduced horizontally, and held fast in its place like a slider by the internal spring. A piece of amalgamated zinc is then dropped into the liquid, but no action takes place. A piece of platinum wire is then thrust into the liquid, but if kept apart from the amalgamated zinc, still no action is apparent. The moment, however, that the wire is brought into contact with the amalgamated lump, pearly bubbles of gas are seen to form on all parts of the platinum. In the engraving, Z is the lump of amalgamated zinc seen in dark profile on the illuminated disk, and the equally dark serpentine line in contact with it is the platinum wire. It will be observed, that notwithstanding the platinum wire is covered with gas, not a single bubble is given off from the amalgam. If the wire is lifted from its contact with the latter, all chemical action and formation of bubbles instantly cease. If again allowed to touch the amalgamated zinc, the gas is generated as at first.

Other modes of the Decomposition of Water, with details of the celebrated experiment of 1781, will be found at pp. 77-79.

CURIOSITIES OF SCIENCE.

(SECOND SERIES.)



Alchemy and Chemistry.

WHAT THE CHEMISTS OWE TO THE ALCHEMISTS.

INESTIMABLE benefits have accrued to mankind from the ancient practice of an art which is now considered, but with some injustice, to have been a low delusion and imposture. "Look into the books of the alchemists, and some idea may be formed of the effects of experiments. It is true, these persons were guided by false views; yet they made most useful researches," and thus laid the foundation of experimental science and modern Chemistry.

Chemistry has been traced to the cradle of civilisation; the name itself being derived by Cuvier from the word *Chim*, which was the ancient name of Egypt. He states that minerals were known to the Egyptians "not only by their external characters, but also by what we at the present day call their *chemical characters*."

Suidas derives the name from the Greek *chemeia*, "the making of silver or gold," or what is now more generally known by the name of Alchemy. Suidas adds that Diocletian burnt all the ancient books in Egypt on chemistry, in order that the Egyptians might no longer be able to acquire wealth by the practice of this art, and thus be encouraged to resist the Romans. This accords with Cuvier's idea that *chemeia* is an Egyptian word; and its resemblance to Cham or Chem, the genuine name of the country, is a confirmation of the supposition as to its origin. The word indicates literally Egyptian art, the art of the black land. The inscription on the Rosetta stone has the word *Chim*.

Among the chemical knowledge of the Romans under the Empire, we find a few experiments by Dioscorides, and the technical art of collecting fluids by the process of distillation.

This famous Greek wrote on *Materia Medica*,—the title of his principal work,—and few books have ever enjoyed such long and universal

celebrity. For sixteen centuries and more this work was referred to as the fountain-head of all authority by every body who studied either botany or the mere virtues of plants. Dioscorides collected his materials for this work by travelling through Greece, Italy, Asia Minor, and some parts of Gaul, gathering plants in his journey, and acquainting himself with their properties real or reputed. He likewise assembled the opinions current in his day concerning the medical plants brought from countries not visited by himself, especially from India, which at that time furnished many drugs to the western markets. From such materials he compiled his *Materia Medica*, wherein between 500 and 600 medical plants are named and briefly described. With this work, up to the commencement of the seventeenth century, the whole of academical or private study on such subjects was begun and ended; and it was only when the rapidly increasing numbers of new plants, and the general advance in all branches of physical knowledge, compelled people to admit that the vegetable kingdom might contain more things than were dreamt of by Dioscorides, that his authority ceased to be acknowledged. It should be added, that although his work shows the amount of *Materia Medica* knowledge in his day, it must not be admitted as evidence of the state of botany at the same period; for Dioscorides has no pretension to be ranked among the botanists of antiquity, considering that the writings of Theophrastus, four centuries earlier, show that botany had even at that time begun to be cultivated as a science distinct from the art of the herbalist.

But Chemistry cannot be said to have begun until men learnt to obtain mineral acids, and to employ them for the solution and liberation of substances; and it is on this account that the distillation of sea-water described by Alexander of Aphrodisia,* under Caracalla, is so worthy of notice. It designates the path by which man gradually arrived at a knowledge of the heterogeneous nature of substances, their chemical composition, and their mutual affinities. — *Humboldt's Cosmos*, vol. ii.

EGYPTIAN ALCHEMY.

The late Sir William Drummond wrote in the *Classical Journal* an elaborate defence of Egyptian Alchemy. He first asserts that the ancient Egyptians could not have possessed gold by any ordinary modes, *inasmuch as they had no mines*, and were not addicted to commerce; yet they constructed vast buildings and public works—such as the Labyrinth, the Lake Moeris, the Pyramids, and the tomb of Osymandias, the golden circle in which Sir William values at 14,000,000*l.* sterling. He quotes Herodotus' statement, that the charge for onions and garlic furnished to the labourers on the Pyramids amounted to 1600 silver talents, *i. e.* about 600,000*l.* sterling. "Gold," observes he, "was so plentiful that the hunter formed his wea-

* Although Alexander of Aphrodisia, properly speaking, gives only a circumstantial description of distillation from sea-water, he draws attention to the fact that wine may likewise be distilled. This statement is the more remarkable because Aristotle (*Meteorol.* ii. 3, p. 358, Bekker) had advanced the erroneous opinion, that in natural evaporation fresh water only rose from wine from the salt water of the sea.

pons and the labourer his tools of this precious metal." After noticing the great hatred with which the Egyptians regarded Cambyzes and his Persian followers, he states that the priests, who alone possessed the power of making gold, concealed it till the accession of the House of Lagos, when they again made known their scientific knowledge. Such are a few of the assumed facts upon which a defence of Alchemy is founded, and such are the arguments by which it is supported. But, first, *the inhabitants of Egypt had gold-mines*, and vestiges of them exist to this day;* next, many learned men deny that the Lake Moëris ever existed, and that the circle or planisphere of gold over the tomb of Osymandias, not being mentioned by Herodotus, is of very questionable existence; nor does he explain how Cheops raised the money to build the great pyramid; and the amount of the charges for food, clothing, tools, and refreshments is ridiculously small; while Herodotus shows that the Egyptian monarchs suffered from an exhausted exchequer, which they need not have done had they made their own gold. Such are the arguments by which Alchemy has been *historically* supported. They are not much better than Borrachius's syllogism—that because the ancient Egyptians hatched eggs in ovens, they therefore possessed the Philosopher's Stone and the Universal Medicine.—Abridged from the Rev. Mr. Christmas's *Cradle of the Twin Giants*, vol. ii.

METALS KNOWN TO THE ANCIENTS.

Gold was the <i>Sun</i> , and was represented thus ☉				
Silver	„	<i>Moon</i>	„	☾
Mercury	„	<i>Mercury</i>	„	☿
Copper	„	<i>Venus</i>	„	♀
Iron	„	<i>Mars</i>	„	♂
Tin	„	<i>Jupiter</i>	„	♃
Lead	„	<i>Saturn</i>	„	♄

The names of planets were chosen from being supposed to have some mysterious relation; and each metal was denoted by a particular symbol, representing both the metal and the planet. This planetary designation, as adopted by the alchemists, forms the basis of some chemical and medical terms now in use. Thus we have *Lunar* Caustic, or fused nitrate of silver; *Martial* pyrites, or native sulphuret of iron; *Mercury* is

* Sir Gardner Wilkinson says, the gold-mines of Egypt, though mentioned by Agatharcides and later writers, and worked even by the Arabian caliphs, long remained unknown; and their position was only ascertained a few years since by M. Lenaut and M. Bonomi, who found Cufic inscriptions showing that the mines were worked in the years 339 A.H. (931 A.D.) and 378 A.H. (989 A.D.). The matrix is quartz; and so diligently did the Egyptians work for the metal, that the veins have been picked out of the fissures and broken into small fragments.

even now as much a term as quicksilver ; and *Saturnine* paralysis is paralysis caused by salts of lead.—*Faraday's Lecture* : Note by Scoffern.

The above explains the association of Astrology and Alchemy. An Oxford Professor has remarked : " It is not a little remarkable how frequently the discoveries of modern days have served to redeem the fancies of mediæval times from the charge of absurdity. If the direction of a bit of steel suspended near the earth can, as Colonel Sabine has proved, be influenced by the position of a body like the moon, situated at the distance from it of more than 200,000 miles, who shall say that there was any thing preposterously extravagant in the conception, however little support it may receive from experience, in the influence ascribed to the stars over the destinies of men by the astrologers of olden time ?"—*Dr. Daubeny, F.R.S.*

THE ARABS.—GEBER.

Hitherto we have only referred in part to the origin of the name *Alchemy*, from the Greek ; whereas, the first syllable, *al*, denotes the probability of the Arabic origin of the art. Dr. Thomson supposes it to have originated with the Arabs when they began to turn their attention to medicine, after the establishment of the Caliphs ; so that if it had been previously cultivated by the Greeks, as there is some reason to suppose, it was taken up by the Arabians, and reduced by them into regular form and order.

The Arabs, we know, exercised a most powerful influence on general natural physics by the advances of chemistry, a science for which this race created a new era. It must be admitted that alchemistic and new-Platonic fancies were as much blended with chemistry as astrology with astronomy. The requirements of pharmacy, and the equally urgent demands of the technical arts, led to discoveries which were promoted, sometimes designedly and sometimes by a happy accident depending upon alchemistical investigation into the study of metallurgy.

Geber, the Arab physician, who lived in the seventh century, is one of the earliest alchemists whose works are extant ; but their genuineness is doubted. He implicitly adopts the principles which lie at the bottom of alchemy ; but he does not attempt to make gold artificially, nor admit the possibility of converting the baser metals into gold. Geber also treats of the Universal Medicine, Tincture, Elixir, and the Philosopher's Stone. Dr. Johnson supposes that the word *Gibberish*, anciently written *Geberish*, was originally applied to the language of Geber and his tribe, and quotations from his works justify the etymology. Geber was an alchemist in the most comprehensive sense word, and his works abound with the absurd and mysteries of the art ; but his *chemical* labours were directed

to the improvement of medicine ; he describes and depicts furnaces, crucibles, alembics, and other useful chemical apparatus, of which he is thought to have been the inventor ; and he treats of distillation, sublimation, calcination, and various other chemical operations. To him we also owe the first mention of corrosive sublimate, the red oxide of mercury, nitric acid, and the nitrate of silver. His sun of "perfection," or instructions to students to aid them in the laborious search for the Stone and Elixir, has been translated into most of the languages of Europe : an English translation, by a great enthusiast in alchemy, one Richard Russell, was published in London in 1686, the preface of which is dated from Newmarket.

Thus the preparation of nitric acid by Geber dates back more than 500 years before Albertus Magnus and Raymond Lully, and almost 700 years before Basil Valentine ; although the discovery of these decomposing (dissolving) acids was long ascribed to the three last experimentalists.

Razes gives the rules for the vinous fermentation of amylum and sugar, and for the distillation of *alcohol*, or *al Kahala*, which in Arabic means the sulphuret or common ore of antimony used by the Arabian women to blacken their eyebrows. According to the dictionary of the Spanish Academy, the alchemists were in the habit of selling this mineral along with ardent spirit, believing that a highly concentrated spirit was the result : hence the word Alcohol, a corruption of *al Kahala*.

HERMES TRISMEGISTUS.

Hermes Trismegistus is generally mentioned as one of the earliest alchemists : from him alchemy has been called the *Hermetic art* ; and the word *hermetic*, still in common use, is derived from Hermes, and employed to denote perfectly close, so that no air can escape ; but the ancient *hermetic seal* was formed by fusing the mouth or extremity of a vessel so as to close it entirely. Still the writings bearing the name of Hermes are undoubtedly spurious. With the view of gaining credence for alchemy, it was also called the Egyptian science ; but, says Cuvier, the art of transmuting metals was a mere reverie the middle ages, utterly unknown to antiquity : "the pretended books of Hermes are evidently supposititious, and written by the Greeks of the lower Empire."

ALBERTUS MAGNUS.

Passing over less celebrated alchemists, we come to Albertus Magnus, a German, born in 1222. In his treatise *De Alchemia* he describes all chemical substances known in his time ; was well acquainted with chemical apparatus, and with

method of purifying the precious metals. He imagined that the metals were composed of mercury and sulphur, and accounts for the diversity of them by the difference in the proportion of their constituents and their purity. His writings are in general plain and intelligible; Thomas Aquinas is believed to have been the pupil of Albert. He wrote three works on alchemy; and the word *Amalgam*,* signifying a compound of mercury and another metal, occurs, and probably for the first time, in his writings, which contain also some other terms still used in chemistry.

RAYMOND LULLY.

Nearly half a century earlier, in 1234, was born, at Majorca, Raymond Lully, stated to have been the scholar and the friend of Roger Bacon. His reputation as an alchemist was very high: he was well acquainted with chemical compounds, and their action upon each other; he obtained nitric acid by distilling a mixture of nitre and green vitriol, observed its power of acting upon metals generally, and of dissolving gold when mixed with sal ammoniac. He appears to have taken Geber for his model late in life.

Lully's history is peculiarly interesting to the English reader from his biographers' stating that, upon the invitation of the sovereign, he settled in England, and in apartments assigned for his use in the Tower of London refined much gold; superintended the coinage of *rose-nobles*, and made gold out of iron, quicksilver, lead, and pewter, to the amount of six millions! That he came to England is attested in a work attributed to him on the Transmutation of Metals, though it is not clear whether he came at the intercession of Edward I. or II. That he was employed in refining gold and in coining, "in the chamber of St. Katherine," in the Tower, is reasonable enough; and rumour may have assigned to him the possession of the grand secret, which he did not contradict. He left many learned works, among which were treatises on physics, astronomy, medicine, and chemistry.

From this it is inferred that Lully lived in the Hospital of St. Katherine, so as to be near the Mint-works in the Tower. In the *rose-noble* the image of the sun, surmounted by the mystical flower, as well as the inscription on the obverse, "*Jesus autem transiens per medium illorum ibat*," must, according to the adepts, be considered as denoting the art which formed the precious metal. Lully was hospitably received by Abbot Cremer in the Abbey at Westminster; and many years after his decease, a little chest, filled with the powder of transmutation, was found in the cell which he had inhabited. Lully had used to make any more money for the king, who had broken condition—that it should be employed in making war upon heathens and unbelievers; whereas Edward had spent the sup-

**Amalgam*, a compound of two or more metals, of which one is always mercury. This circumstance distinguishes an *amalgam* from a mere *alloy*.

plies in his wars with the Scots. In the dispute which followed, the king waxed wroth, and, as Ashmole relates, confined Lully in the Tower, where he remained for a long time, and at length escaped in the disguise of a leper.

THE PHILOSOPHER'S STONE.

In the thirteenth century arose for the first time the idea that the Philosopher's Stone had the power of healing disease and of restoring youth. This idea was developed from the opinion that the vital process was nothing else than a chemical process. With the Philosopher's Stone it was possible to heal metals of their maladies, to render them healthy, and convert them into gold; and the idea that it must have a like effect upon the human body naturally suggested itself. Hollandus, in his *Opus Saturni*, says of the healing virtues of the Stone: "A portion of it, the size of a grain of wheat, should be laid in wine, and then given to the patient. The action of the wine will penetrate to the heart, and spread itself through all the juices. The patient will sweat, and therefore become not more weary, but even stronger and more cheerful. This dose should be repeated every ninth day, when the patient shall think he is no longer a man, but a spirit. He shall feel as if he were nine days in Paradise, and living on its fruits." Solomon Trimousin maintains that, when an old man, he renewed his youth by means of a grain of the Philosopher's Stone! His yellow wrinkles became smooth and white, his cheeks rosy, his gray hairs black, his back, bowed with age, became erect. He restored, as he asserts, perfect youthfulness to ladies ninety years of age!

This was, however, the abuse of the preëminence which the scientific men of that early age had obtained. "The expectations of the alchemists to find a Universal Medicine were not altogether irrational and useless. The success of the Arabian physicians in the use of mercurial preparations naturally led to the belief that other medicines still more general in their healing powers might yet be brought to light; and we have no doubt that many important discoveries were the result of such over-strained expectations; but when the alchemists pretended to have obtained such a medicine, and to have conferred longevity by administering it, they did equal violence to reason and to truth."—*Sir D. Brewster.*

In all metals (says Liebig), according to the creed of the alchemists, there is contained a principle which gives to them the metallic character. This is the *mercury of the adepts*. To increase the proportion of this principle in the baser metals, is to ennoble them. If we extract this metallic principle from any body or metal, if we increase its power by refining it, and thus produce the quintessence of all *metallicity* (to

coin a word), we have the Stone, which, when made to act on base or unripe metals, matures and ennobles them. The mode of action of the Philosopher's Stone was considered by many as analogous to that of a ferment. "Does not yeast change the juice of plants or a solution of sugar, by a new arrangement of their particles, into the youth-giving and invigorating water of life (*aqua vita*, alcohol)? Does it not effect the expulsion of all impurities? Does not a ferment (sour dough) convert flour into nourishing bread?"—*George Rippel*, 15th century.

In its utmost perfection, as the *universale*, one part, according to Roger Bacon, sufficed to transmute a million parts, according to Raymond Lully, a thousand billions of parts, of a base metal into gold. According to Basil Valentine, the power of the Philosopher's Stone extends only to seventy parts; and Dr. Price, the last alchemist and gold-maker of the eighteenth century, describes it as transmuting only from thirty to sixty parts of base metal.—*Liebig's Familiar Letters on Chemistry*.

The preparation of the Philosopher's Stone is thus briefly given by Isaacus Hollandus: From the adamite earth—virgin earth—to be found every where, but on certain conditions known to the initiated alone, "the philosopher obtains, first, the mercury of the adepts, which differs from the ordinary quicksilver, and is the quintessence—the first condition—of the creation or procreation of all metals. To this is added philosophical gold, and the mixture is left for a long time in an incubatory, or brooding furnace, which must have the form of an egg. There is thus obtained a black substance, the raven's head, or *caput corvi*, which, after long exposure to heat, is converted into a white body. This is the white swan, *cygnus albus*. After this has been long and more fiercely heated, it becomes yellow, and finally bright red, and now the great work is consummated."

Yet, although the existence of the Stone was regarded for centuries as an established truth, no one possessed it; each adept only maintaining that it was in the possession of another.

ROGER BACON.

One of his contemporaries, Roger Bacon, possessed a much greater mind than Lully; and although he believed in the production of the Philosopher's Stone, and wrote a *Mirror of Alchemy*, he made its study secondary to other pursuits after universal knowledge: indeed, his astrology and alchemy are usually called the two great blots on his character. He is the "Friar Bacon" of the story-books; and the circumstance of his being a Franciscan destined him to many years' persecution on account of his discoveries during his lifetime, and to the low reputation of being an impostor for centuries after his death. But he was not only the greatest man of his time, but was many centuries in advance of his age. He was born about 1214, and was educated at that seat of early science, Merton College, Ox-

ford. "Neglecting common opinion," he studied physiology, mathematics, and chemistry; spent ten years on geometry, and ten others on the cognate sciences; while he laid out 2000*l.*, an enormous sum in those days, in the purchase of books, the construction of instruments, and the training up of young scholars to assist him in working out his calculations. Bacon then became a Franciscan. The order at first felt proud of possessing the greatest scholar in Christendom; but the monks soon grew jealous, and he was forbidden to teach, or even to study, until Clement IV. overruled the friars, and Bacon soon produced his *Opus Majus*, the first portion of a work to convey the totality of science. This was succeeded by two other treatises, the *Opus Minus* and the *Opus Tertium*. After Clement's death, Bacon's order again imprisoned him on account of "some suspected novelties;" he lived until 1292; but his enemies still feared him, and his manuscripts were locked up by the monks, and left to be eaten by insects!

Bacon was a great founder of physical science by his wise doubts and reverence for facts. He speaks of experimental philosophy as more perfect than all the natural sciences; "for it teaches us to test by trial the noble conclusions of all the sciences, which, in the others, are either proved by logical arguments or are examined on the imperfect evidence of nature; and this is its prerogative." As a workman in the laboratory, and with lenses, he himself discovers the history of explosive compounds, confirms the properties of burning-glasses, and the principle of the camera. His knowledge of medicine even extended to dietetics. In physical science he almost predicts the steam-boat and the railway-engine and the beam-bridge; Bacon believing that "engines of navigation may be made without seamen, so that the greatest river and sea ships, with only one man to steer them, may sail swifter than if they were fully manned. Moreover chariots," he thinks, "may be made so as to be moved with incalculable force without any beast drawing them." "And such things might be made to infinity, as, for instance, bridges to traverse rivers without pillars or any buttress." Although in these instances Bacon may have been rather a prophet than a teacher, he is admitted to have been by far the truest philosopher of the middle ages. One of the charges made against him was that of practising magic, which was then frequently brought against those who studied the sciences, and particularly chemistry. Yet in his tract *De Nullitate Magiæ* Bacon declares that experimental science enables us to investigate the practices of magic, not with the intent of confirming them, but that they may be avoided by the philosopher. Even his astrology and alchemy are, when considered by the side of a later age, irrational only because

unproved; and neither impossible, nor unworthy of the investigation of a philosopher in the absence of preceding experiments.

ARNOLD DE VILLENEUVE.

Somewhat later than Lully lived Arnold de Villeneuve, born in 1240, and who was not only an alchemist, but an astrologer and magician, a physician, and well skilled in the sciences of his time. His *Rosarium* is a compendium of the alchemy of his day: the second part professes to treat of the making of the Philosopher's Stone, but is quite unintelligible. Like his predecessors, he considered mercury as a constituent of metals, and professed that he could increase the Philosopher's Stone at pleasure. He and Lully inspired men of all ranks with a taste for alchemy; among whom was Pope John XXII., who professed and described the art of transmuting metals, and boasted that he had made 200 ingots of gold, each weighing 100 pounds!

ALCHEMISTS OF THE 14TH AND 15TH CENTURIES.

The fourteenth century produced many alchemists; but the fifteenth century was still more productive in *adepts*—a term, by the way, which has passed from the technology of alchemy to that of chemistry, and thence into our language to denote persons completely skilled in the secrets of art. About 1408 flourished two kinsmen named Hollandus, who wrote several treatises on chemistry remarkable for clearness and precision; Boerhaave considered the kinsmen skilful chemists.

In England, a legislative blow was aimed at Alchemy in 1404, when an Act of Parliament was passed declaring the making of gold and silver to be felony. This shows the general belief in the art, since the law arose from the fear that some fortunate alchemist should succeed in his project, and thus bring ruin on the State. This alarm soon subsided; for in 1455 Henry VI., by advice of his council and parliament, granted patents and commissions to several knights, citizens of London, chemists, monks, mass-priests, and others, to find out the Philosopher's Stone and Elixir, "to the great benefit," said the patent, "of the realm, and the enabling of the king to pay all the debts of the Crown in real gold and silver." No gold, of course, was ever made. The king appointed a commission to inquire whether the transmutation of metals were practicable; but their report is not extant.

In this reign, at the east end of the road subsequently known as Pall Mall, stood a large low Gothic building, called the Rookery, belonging to the monks of Westminster. At the Reformation, when this building was demolished, there is a tradition that in a corner of an inner apartment the remains of a smithy

were found, with a timber roof thickly incrustated with bituminous smoke. This smithy or forge was reputed to have been erected by order of Henry VI., that he might there attempt to replenish his empty coffers by alchemy: the record of this proposition contains solemn asseverations of the feasibility and virtue of the Philosopher's Stone; and the document is presumed to have been communicated by Selden to his friend Ben Jonson, when he was writing his comedy of the *Alchemist*, which, like *Albumazar* (in Dodsley's collection), satirises pretended adepts. Upon the site of the smithy in Pall Mall was built the first Carlton House.

GEORGE RIPLEY.

In the succeeding reign, George Ripley, the canon of Bridlington in Yorkshire, pretended to have discovered the secret. He wrote the *Medulla Alchymicæ*; and, in rugged rhyme, *The Compound of Alchemy; or, the Twelve Gates leading to the Discovery of the Philosopher's Stone*, which was dedicated to Edward IV. These gates Ripley described to be "calcination, solution, separation, conjunction, putrefaction, congelation, cibation, sublimation, fermentation, exaltation, multiplication, and projection." He left a few other compositions on Alchemy, which were printed by Ashmole. "They have no other merit (says Warton) than that of serving to develop the history of chemistry in England." Ripley is said to have been born at Boston, by others at Ripley in Yorkshire. His discovery of the Stone is dated 1470. Selden says: "Ripley, the alchemist, when he made gold in the Tower, the first time he found it, spoke these words, "*per medium eorum*, that is, *per medium ignis et sulphuris*." He turned Carmelite at St. Botolph's in Lincolnshire, and died an anchorite in that fraternity, in 1490. (Thompson's *History and Antiquities of Boston*, 1856.) Ripley appears to have repented of his wasted life, to have acknowledged that his studies were nothing worth, and requested that all men, when they met with any of his books, would burn them, or afford them no credit, as they were "false and vain." Such is the statement of Fuller, in his *Worthies of England*.

BASIL VALENTINE.

Basil Valentine, a Benedictine monk of Erfurt in Germany, born about the end of the 14th century, was the next famous professor of the hermetic philosophy, and was likewise a skilful experimentalist in chemistry. He was of opinion that the metals were compounds of salt, sulphur, and mercury; and that the Philosopher's Stone was composed of the same ingredients. He was acquainted with many of the properties of several metals, and with the effects of their chemical agency. He first

introduced antimony into medicine, and knew most of the preparations of it which at present exist in the pharmacopœias of Europe. In his famous *Currus Triumphalis Antimonii*, he says: "Antimony, like unto mercury, may fitly be compared to a round circle, of which there is no end; in which the more diligently any man seeks, the more he finds, if process be made by him in a right and due order. *Yet the life of no one man is sufficient for him to learn all the mysteries thereof.*" With what astonishment would Basil, if he could revisit the earth for half an hour, hear of antimonious, antimonie, and metantimonie acids; of antimoniuretted hydrogen, penta-sulphide of antimony, stibio-methyle, stibio-ethyle, and the like. The coaches of his day did not differ more from the railway-carriages of ours than his "*Currus Triumphalis*" does from such a Triumphant Chariot of Antimony as Hofmann, if he chose, could mount upon literary wheels at the present day. Yet Hofmann could find no better motto to put upon the panel of his chariot than Basil's words, "No one knows all the virtues of Antimony;" and I may add (says Dr. Wilson), no man ever will; nor is the chemist better off in respect to other things than he is in respect to Valentine's favourite metal.* His works contain the first accurate mention of the nitric, muriatic, and sulphuric acids, with intelligible directions for preparing them; and he was acquainted with a very considerable number of metallic salts and compounds.

AGRIPPA.

Cornelius Agrippa, born in Cologne in 1486, began in his youth the study of chemistry and philosophy; and at the early age of twenty was so famous an alchemist that the principal adepts of Paris invited him to settle in France, and aid them with his experience in discovering the Philosopher's Stone. He was professedly a physician; but allowed himself to be regarded as an alchemist, an astrologer, and even as a practitioner of magical arts. He died in poverty in 1535.

PARACELSUS.

Paracelsus, "the zenith and rising sun of all the alchemists," was born near Zurich at the close of the fifteenth century. He was early initiated into the secrets of astrology and alchemy by his father, who was a physician, and by the Abbé Trithreim. He passed his youth in visiting mines, curing diseases, foretelling the future, and seeking the Philosopher's Stone. He is said to have learned a few secrets of alchemy from some Tartars, by whom he was made prisoner in Poland; and he obtained some further mysteries in a journey to Egypt.

* From Dr. George Wilson's admirable Essay on Chemical Final Causes (*Edinburgh Essays*, 1866).

He read little, but talked and listened to all classes. Alchemy was at this time falling into discredit, when Paracelsus undertook to revive and rehabilitate the study. In 1526 he returned to Switzerland, where a lucky and striking cure led to his being appointed Professor of Physic and Surgery at Basle. He there set himself in opposition to all doctors, past and present, when the students joined him in his attack upon the Schools, and burned the writings of Hippocrates, Galen, and Avicenna in the very court of the University. Some lucky cures confirmed his reputation, but it lasted only a short time. He flew to dissipation, became a wandering quack, and died in his forty-eighth year. As a medical reformer, he propounded a novel and striking Physiology. Nevertheless he broke down in his two great pretensions; for this boasted possessor of the Philosopher's Stone and the Elixir of Life died in poverty at an early age. His discoveries were, however, important. To him we owe the idea of employing poisons as medicines; he made known to Europe various preparations of antimony, mercury, iron, &c.; he employed preparations of lead for diseases of the skin, and first used copper, arsenic, and sulphuric acid as medicaments. "The vaunts of Paracelsus of the power of his chemical remedies and elixirs, and his open condemnation of the ancient pharmacy, backed as they were by many surprising cures, convinced all rational physicians that chemistry could furnish many excellent remedies unknown till that time. A number of valuable experiments began to be made by physicians and chemists; and the chemical and metallurgic arts, exercised by persons empirically acquainted with the secrets, began to be seriously studied, with a view to the acquisition of rational and useful knowledge."

Paracelsus therefore gave a most important turn to pharmaceutical chemistry; and calomel, with a variety of mercurial and antimonial preparations, as likewise opium, thenceforth came into general use. He had learned the properties of opium from Turkey; the physicians of his time being afraid of this drug as "cold in the fourth degree." Tartar was likewise a great favourite of Paracelsus, who gave it that name, "because it contains the water, the salt, the oil, and the acid which burn the patient as hell (Tartarus) does." Such was the influence of Paracelsus, that a sect of Paracelsists sprang up in France and Germany to perpetuate his extravagant doctrines, and the term Paracelsic was afterwards applied to the vocabulary of alchemists. His magical doctrine appears to have been founded upon the supposed existence of the Philosopher's Stone. He maintained that the Bible was the key to the theory of all diseases, and that the Apocalypse shows the signification of modern medicine. The man who could identify

himself with the celestial intelligences possessed the Philosopher's Stone, he could cure all diseases, and prolong life as many centuries as he pleased ; it being by the very same means that Adam and the antediluvian patriarchs prolonged theirs. In the stomach of every man there dwelt a demon, or intelligence, that was a sort of alchemist, and mixed in their due proportions, in his crucible, the various aliments that were sent into that grand laboratory the belly. Paracelsus was proud of the title of magician, and advocated potable gold and the Elixir of Life. He imagined that gold could cure the ossification of the heart, and, in fact, all diseases, if it were gold which had been transmuted from an inferior metal by means of the Philosopher's Stone, and if it were applied under certain conjunctions of the planets. Thus we see that his application of the Stone was to the curing of diseases.

BAPTISTA PORTA.

Porta, in the book of his *Natural Magic* which he devotes to "Alchemy," is strangely inconsistent. He acknowledges that he neither promised the Stone nor the Elixir, which are mere dreams. He commends Dioclesian for having destroyed the treatises on Alchemy ; and agrees with Demetrius Phalereus, "that what the alchemists should have gotten, they got not ; that what they had, they lost ; and the transmutation which they sought took place, not in the metal in their furnaces from lead to gold, but in their own circumstances from good to bad." Yet, in the very next chapter, Porta treats "of tin, and how it may be converted into a worthier metal ;" and he even tells us how to change silver into gold, though sometimes he seems to consider his recipes as genuine, and at other times as clever impositions. He next treats of counterfeiting precious stones, not by solution and recrystallisation, but by colouring glass, and putting coloured foil under the setting.

ALCHEMISTS AND COINERS.

In the reign of Elizabeth, certain persons who, by the practice of Alchemy, proposed to add to or imitate the Queen's coin, were committed prisoners to the Tower of London.

"The chief of these was Cornelius de Launoy, an alchemist, who gravely proposed to the Queen to put in operation the Wonderful Elixir, and to make any metal into gold and gems. He so far succeeded with her as to be allowed to carry on his works at Somerset House. Of course he failed : on being reported to have greatly abused the Queen's confidence, he was committed to the Tower in 1566, where he still professed to be able to perfect his experiments, had it not been for the obstacles thrown in his way.

“In July 1570, two other alchemists, who had been inclined to practise on their own account, were also favoured with an asylum here: they were John Bulkeley, a student at Oxford, and William Bedo, a stationer, who proposed to cast a figure for the recovery of lost money, and professed to have many alchemical secrets for diminishing and lessening the coin of the realm by sweating, &c.”—*M. W. Durrant Cooper, Archæologia*, vol. xxxvii.

DEE AND KELLY.

Dr. Dee, and his assistant Edward Kelly, were more notorious as practitioners of magic than of alchemy. Dee, when at Cambridge, quitted the mathematics and the pursuits of true philosophy for alchemy, astrology, and magic, and thereby rendered himself obnoxious to the authorities of the University. He was suspected of sorcery; and to avoid persecution, he fled to Louvain, where many followers of Cornelius Agrippa encouraged him to give himself up to the search for the Philosopher's Stone. Upon his return to England, he settled in London as an astrologer, casting nativities, telling fortunes, and pointing out lucky and unlucky days. He was charged with attempting Queen Mary's life by means of enchantment, and narrowly escaped burning in Smithfield. Though Dee lived by astrology, his heart was in alchemy. He deeply studied the Talmudic mysteries, and believed that he might hold converse with spirits and angels, and learn from them all the mysteries of the universe. He persuaded himself that an angel appeared to him, and gave him a crystal, in which spirits would appear to him; and he similarly employed a “show-stone,” a piece of polished cannel-coal. He then employed Kelly to take down in writing the revelations he received from the spirits; but the man was much more of an impostor than his master. Meanwhile Dee, who had enjoyed the favour of the Princess Elizabeth, was counselled by him as to her coronation-day, and Elizabeth supported him when queen: she consulted him at his house at Mortlake upon state matters, and thither crowds flocked to have their nativities cast. He pretended to have found a vial of *Elixir Vitæ* among the ruins of Glastonbury Abbey; but he is stated to have spent so much in drugs and metals to work out his transmutations that he never became rich. He made a long tour on the Continent, and gained dupes even among crowned heads: while there, he sent to Queen Elizabeth a round piece of silver, which he pretended he had made of a portion of brass cut out of a warming-pan. At length he parted with Kelly; and thrown upon his own resources, began in earnest to search for the Philosopher's Stone: he worked incessantly among his

furnaces, retorts, and crucibles ; he consulted his crystal.* But having parted with Kelly, who had been the main-spring of the imposition, the spirits would not appear ; he tried other help-mates, but without success ; he could get no information on the Stone or Elixir, and so fell into want. During his absence from England, a mob had pillaged his house at Mortlake, and had burnt his books, and destroyed his instruments and curiosities in his museum, accusing him of being a necromancer and wizard. For this damage he claimed compensation, but received only small sums from the Queen. He, however, was subsequently appointed Warden of the College at Manchester, which post he resigned in seven years, and then returned to Mortlake, where he died in poverty in 1608, and was buried in Mortlake church. Dee had a son, Arthur, whom he employed as a *skryer*, or inspector of his magical glass, when he was a boy. He wrote a tract on Alchemy, or the Hermetic Science, published in 1631.

SIR THOMAS BROWNE AND THE ALCHEMISTS.

Sir Thomas Browne, in letters to Lilly and Ashmole, bears testimony most unequivocally to the sincerity of Dr. Arthur Dee's belief in the power of alchemy to transmute the baser metals into gold and silver, which he assured Sir Thomas he had "ocularly, undeceivably, and frequently" beheld. He was even on the point of going to the Continent in pursuit of such riches, had not the death of the artist, with whom he was about to hazard his property, most opportunely prevented him. Sir Thomas had also another zealous alchemist among his correspondents, in the person of Sir Robert Paston, with whom he communicated from 1663 to 1672, principally on experiments which Sir Robert was making in alchemy. But Browne himself did not place any reliance upon alchemical studies, which, however, he regarded as the cradle of chemistry.

SERVICES OF ALCHEMY TO MEDICINE.

The Pharmacopœia of the Galenical school contained no chemical preparations, and consisted exclusively of organic substances : musk, rhubarb, castoreum, camphor, tamarinds, ginger, zedoary root, and the like, were the chief remedies. Pharmacy then consisted in the art of bringing these matters into the form of syrups and electuaries ; herbs, barks, and roots were administered in the form of decoctions or of powders. On the authority of Galen, all metallic preparations were up to that time banished from the Pharmacopœia. He regarded mercurial preparations simply as poisons. Avicenna, it is true,

* See the account of Dee's Crystal in *Popular Errors Explained*, p. 143.

had ascribed to gold and silver powers of purifying the blood; but these metals, as a general rule, were used only in the form of leaf to cover pills;* and so late as the end of the fifteenth century, the external use of mercurial ointments, prepared with fat, encountered the fiercest opposition.

The views of Galen as to the cause of disease and the action of remedies, after having been for thirteen centuries regarded as impregnable truths, in the sixteenth century yielded to the discovery of the truly wonderful effects of the preparations of mercury, antimony, and other metals, when a whole region of new discoveries seemed to be opened up by the ideas of the alchemists, and by the use of chemical preparations in medicine.

THE TWO NAPIERS, ALCHEMISTS.

Some original documents among the family archives of Napier of Merchiston, the inventor of *Logarithms*, prove this great philosopher was a believer in the doctrines of Hermes. One of these documents records, on Nov. 7, 1607, Napier's conference with Mr. Daniel Muller, Doctor of Medicine and Student in Alchemy, at whose bedside Napier declares himself to have been many years a very earnest student in alchemy; and to have received from a credible friend, whom he sent to the mines of Histria, a Venetian province at the top of the Adriatic, "a little piece of the earth of those mines, about the quantity of a hazel-nut, which, as he brake, there appeared scales of quicksilver within the same, and the crude mercury flowed forth without the fire. With this (says Napier) I perfected the philosophical work, as you may do with the like; for this mercury, being taken with fine silver which never did find fire, and enclosed in a matrix, will become black within the space of forty days, and thereafter will become white: and then is the point and term to loose it, if you do not join it with fine gold that never did find the fire, when instantly that which was taken of mercury and *luna* (or silver) will devour up the gold; and at this conjunction or fermentation endeth the first work, called *opus lunæ* (the silver operation), and beginneth immediately the second, called *opus solis* (the golden operation).

In this *opere solis* your work becomes blacker than in *opere lunæ*, and then white, and at last red.

Both these works are performed in a year, to wit, two months and a half in *opere lunæ*, and nine months and a half in *opere solis*.

And for *pondera* I take nine of crude mercury for one of crude *luna* (or silver), and this I conjoin with one of *sol* (or gold) in *secundo opere*.

So *luna* is the *medium conjungendi*; and hereof cometh three mer-

* The arms of the Medici of Florence were three gilded pills, in allusion to the professional origin of their name. Indeed, medical signs were generally gilded; as the *Golden Key*, Galen's Heads, and the *Golden Pestle and Mortar*. We remember the latter sign in Pall Mall, at the house next to which lived Dr. Sydenham. The *Golden Phœnix* is directly of hermetic origin.

curies, to wit, the first, which is *mercurius crudus*, and is called *mercurius frigidus, acetum, mercurius mineralis*; the second, which is *luna* dissolved in crude mercury to the point of whiteness, is called *mercurius tepidus, acetum, acerrimum, mercurius vegetabilis, quia luna est planta* (because silver is the root); the third, which is *sol* dissolved by the second, is called *mercurius calidus, mercurius animalis*.

'Further,' said he (Dr. Muller), 'the little cipher-table entitled "*Medulla Philosophiæ Hermeticæ*," it is mine, for I made it.'

Also he added many discourses, citing texts out of Clangor Buccinæ, Marsilius, Ripleus, and Arnoldus, to prove the premises, and especially '*De Terra Nigra Occulosa, Terra Hispanica*,' &c.

Further, he said that the various-hued glass which I did see was in that manner, throughout all its texture, coloured with the stuff which he made in that same glass.

Further, he spake to the *triplici usu lapidis*, after Paracelsus: first, in transmutations of metals; secondly, in curing diseases; and thirdly, it is *lapis divinus*, for magical uses.

Now when I heard these things, and had said unto him, 'My lord, that matter is marvellous, if you be sure of the truth thereof by practice,' he answered, with earnestness, 'In truth I have practised it to the end, and made projection, and found it true.'

Again, when I demanded of him how it fortun'd that he did not multiply his stuff, and keep the same, he answered, 'I lacked crude mercury, without which it cannot be multiplied again.'

Upon the 9th of November, I conferred with him again anent some doubts, *quod fons trahit regem, et non rex fontem*, and so doth *aqua regis*; but vulgar mercury, on the contrary, *non trahit solem, sed sol eum*! He answered, that whatever vulgar mercury or crude mercury do, yet this mercury philosophical, of crude mercury and silver, will instantly drink up gold, and draw it in, *initio secundi operis*. Then I demanded when should the second work begin, and what was the sign before the point of danger to the work. He answered, that after perfect whiteness in *opere primo*, there would appear, in an instant, a small hair-like circle surrounding the matter, and attached to the sides of the vessel; then instantly ferment with gold, and it will presently eat up all the gold, and that circle will vanish; but if you stay longer in fermenting, the work will become all *citrine*, and more dry than it can dissolve the gold; for the gold must be sown in *terram albam foliatam*.

Then I demanded what *terra alba foliata* was. He answered, that at the point of whiteness, in the first operation, the matter of mercury and *luna* became like the small scales of a fish. Then I remembered that my father showed me that he made a work which became *terra alba foliata*, most like the leaves of a book set on edge, of *sol, luna, aqua regis*, and *aqua fortis*.

Thereafter, about the 15th day of March 1608, the doctor showed me that he had received glad tidings of the safe return of Lionel Struthers, his said friend, from Histria, to England; and he showed me a certain antique figure, with certain verses of congratulation which he had made, and was sending to him in joy of his safe return.

So, within ten days, he came to Edinburgh to the Doctor, and brought with him great store of mineral mercury, which never had felt fire, and some unfined, easy to be wrung out from his ore. The Doctor gave me secretly a small portion both of the one and of the other; as also a very small part of *luna* mineral unfined; but I purchased more, both of Scotch and German *luna*. As for *sol* (gold) mineral, we have enough in Scotland, rests time and opportunity to enterprise the work, with the

blessing of God to perform the same, to his glory and comfort of his servants, which the Almighty grant to us, whose holy name be praised and magnified for ever and ever. Amen."

From another Ms. preserved in the Napier charter-chest, written subsequently to the death of the inventor of logarithms by his younger son, Robert Napier, faith in alchemy would appear to have been on the increase. The son had toiled far more devotedly than his somewhat sceptical father. Robert, by extracting the marrow of all the hermetic philosophers and authors who preceded him, professed to bequeath to his son the grand secret itself! It is written throughout in Latin. In the preface he states :

It has been ordained by Divine Providence that this science should be transmitted to us from Hermes, its first inventor, down even to these times, a period of nearly four thousand years, through the hands of the learned—the majesty of the great mystery being protected in a cabalistic form. That such a science exists has also been made known to us through books ; but these, for the most part, are so full of enigmas, allegories, and figures of speech, nay of falsities, mystifications, and contradictions, that they seem rather to have been written for misleading than for instructing. Long would be the time, and weary the wandering in error, ere this divine art could be acquired by any one from the books of the philosophers, without a faithful guide.

SIR ISAAC NEWTON'S BELIEF IN ALCHEMY.

We gather from a chapter in Sir David Brewster's *Life of Sir Isaac Newton* some testimony to Sir Isaac's belief in Alchemy, and his early taste for practical chemistry, which he doubtless first acquired during his residence with Mr. Clark the apothecary at Grantham. In April 1669, he records the purchase in London of "aqua fortis, sublimate, oyle pink, fine silver, antimony, vinegar, spirit of wine, white lead, salt of tartar, &c., together with a furnace and an air-furnace."

Sir David says, "in Newton's chemical studies his mind was impressed with some belief in the doctrines of Alchemy, and he certainly pursued his experiments to a late period of his life, with the hope of effecting some valuable transmutations." Among the subjects which he requests his young friend Mr. Aston, about to make a tour on the Continent, to pay attention to, there are several which indicate this tendency of Newton's mind. "He desires him to observe the products of nature, especially in mines, with the circumstances of mixing and of extracting metals or minerals out of their ores, and refining them ; and, what he considered of far more importance than this, he wishes him to observe if there were any transmutations out of one species into another ; as, for example, out of iron into copper, out of one salt into another, or into an insipid body, &c. Such transmutations," he adds, "are above all others worth his noting, being *the most luciferous, and many*

times luciferous experiments too, in philosophy!" He also names "a certain vitriol which changes iron into copper," and which is said to be kept a secret for the lucrative purposes of effecting that transmutation. He is to inquire also whether in Hungary, or in the mountains of Bohemia, there are rivers whose waters are impregnated with gold, dissolved by some corrosive fluid like aqua regis; and whether the practice of laying mercury in the rivers till it be tinged with gold, and then separating the gold by straining the mercury through leather, be still a secret or openly practised. There was at this time in Holland a notorious alchemist of the name of Bory, who, as Sir Isaac says, was some years since imprisoned by the Pope, in order to extort from him secrets of great worth both as to medicine and profit, and who made his escape into Holland, where they granted him a guard. "I think," adds Sir Isaac, "he usually goes clothed in green. Pray inquire what you can of him, and whether his ingenuity be any profit to the Dutch!" Whatever were the results of Mr. Aston's inquiries, they did not damp the ardour of Newton in his chemical researches, nor extinguish the hope which he seems to have cherished of making "philosophy luciferous by transmuting the baser metals into gold."

The Rev. Mr. Law has stated that there were found among Sir Isaac's papers large extracts out of Jacob Behmen's works, written with his own hand; and that he had learned from undoubted authority that in a former part of his life he was led into a search of the Philosopher's Tincture from the same author. He afterwards stated in a private letter that his vouchers are names well known, and that they have assured him that "Sir Isaac was formerly so deep in Jacob Behmen, that he, together with Dr. Newton, his relative, set up furnaces, and were for several months at work in quest of the Tincture. That this statement is substantially true is proved by Dr. Newton's own letter, in which he says: 'About six weeks at spring, and at y^e fall, y^e fire in the laboratory scarcely went out, which was well furnished with chymical materials, as bodyes, receivers, heads, crucibles, &c., which was made very little use of, y^e crucibles excepted, in which he fused his metals. He would sometimes, tho' very seldom, look into an old mouldy book which lay in his laboratory. I think it was titled *Agri-cola de Metallis*; the transmuting of metals being his chief design, for which purpose antimony was a great ingredient. Near his laboratory was his garden. . . . His brick furnaces, *pro re nata*, he made and altered himself, without troubling a bricklayer.'

Sir David Brewster has seen, in Newton's handwriting, *The Metamorphoses of the Planets*, by John de Monte Snyders, in

sixty-two pages quarto; also, a Key to the same work, and numerous pages of alchemist poetry from Norton's *Ordinal* and Basil Valentine's *Mystery of the Microcosm*. There is also a copy of *Secrets Revealed; or, an open entrance to the Shut Palace of the King*,* which is covered with notes in Sir Isaac's hand, in which great changes are made upon the language and meaning of the thirty-five chapters of which it consists. Sir David has likewise found amongst Sir Isaac's papers a beautifully written but incomplete copy of William Yworth's *Processus Mysteriorum magni Philosophici*, and also a small manuscript in his handwriting entitled *Thesaurus Thesaurorum sive Medicina Aurea*.

Newton too left behind him, in his note-books and separate Mss., copious extracts from the writings of the alchemists of all ages, and a very large *Index Chemicus* and *Supplementum Indicis Chemicæ*, with minute references to the different subjects to which they relate.

BOYLE'S PROCESS FOR "MULTIPLYING GOLD."

In 1692, while Newton was in correspondence with Locke, the process of the Hon. Robert Boyle for "multiplying gold," by combining a certain red earth with mercury, became the subject of discussion. Boyle had, before his death, communicated this process both to Newton and Locke, and procured for them some of the red earth. It is obvious from letters extant that both the philosophers were desirous of "multiplying gold." Newton says that several chemists were engaged in trying the process, adding that Mr. Boyle, in communicating it to himself, "had reserved a part of it from my knowledge, though I knew more of it than he has told me."

This mystery on the part of Boyle (says Brewster) is very remarkable. In "offering his secret to Newton and Locke, he imposed conditions upon them, while, in the case of Newton at least, he did not perform his own part in the arrangement." On another occasion, when he communicated two experiments in return for one, "he cumbered them," says Newton, "with such circumstances as startled me, and made me afraid of any more."

It is a curious fact, as appears from this letter, that there was then a company established in London to multiply gold by this recipe, which Newton "takes to be the thing for which Mr. Boyle procured the repeal of the Act of Parliament against multipliers." The pretended truths in alchemy were received by men like Boyle on the same kind of evidence as that by which the phrenology and clairvoyance of modern times have been supported. Although Boyle possessed the golden recipe for

* By W. C., Lond., 1699, 8vo. "Composed by a most famous Englishman, styling himself *Anonymus*, or *Euræneus Philaletha*, who, by inspiration and reading, attained to the Philosopher's Stone at the age of twenty-three years. Anr. Domini, 1645."

twenty years, yet Newton could not find that he had "either tried it himself, or got it tried successfully by any body else; for," he says, "when I spoke doubtingly about it, he confessed that he had not seen it tried, but added, that a certain gentleman was now about it, and it succeeded very well, so far as he had gone, and that all the signs appeared so well that I need not doubt of it."

Boyle, in his physical inquiries, insisted upon the importance of individual experiments, and the comparative unimportance of the facts which on certain subjects antiquity has handed down. Humboldt well calls him "the cautious and doubting Robert Boyle." He even gave to his most popular work the title of *The Sceptical Chemist*, implying how sceptical he was of the science of his own time; and he often avows his doubt and diffidence of the opinions he inclines to. Yet amidst this legion of difficulties of belief, Boyle believed in the efficacy of Valentine Greatrakes's cure of the Evil, and even contributed to the *Philosophical Transactions*, No. 256, an account of Greatrakes, founded upon his own letter addressed to Boyle. A century and a half since, Boyle's *Works*, from their popularity, were becoming scarce; and Dr. Johnson, in the last century, considering how much of our philosophy is derived from Boyle's discoveries, held his writings to be neglected, though his name was revered. A reaction in the demand for his *Works* has sprung up; and at the time we write (1860), in accordance with the inquiring, not to say sceptical, spirit of the times, Boyle is again in great request. A handsome edition of his *Occasional Reflections* was reprinted at Littlemore, and published at Oxford in 1848, and is already scarce. It is a delightful "occasional" book; worth a cartload of light literature.

BELIEF OF GREAT MEN IN ALCHEMY.

There is no problem (says Sir David Brewster) of more difficult solution than that which relates to the belief in Alchemy, and to the practice of its arts, by men of high character and lofty attainments.

When we consider that a gas, a fluid, and a solid may consist of the very same ingredients in different proportions; that the same elements, with one or more atoms of water form different substances; that a virulent poison may differ from the most wholesome food only in the difference of quantity of the very same ingredients; that gold and silver, and, indeed, all the metals, may be extracted from transparent crystals, which scarcely differ in their appearance from a piece of common salt or a bit of sugar-candy; that *Aluminium*, a metal with almost all the valuable properties of gold and platinum, can be extracted from clay; that light of the most dazzling colours can be obtained from the combustion of colourless salts; that gas giving the most brilliant light resides in a lump of coal or a block of wood; that several of the gems can be crystallised from their elements; and that diamond is nothing more than charcoal,—we need not wonder that the most extravagant expectations were entertained of procuring from the basest materials the precious metals and the noblest gems. In the daily experiments of the alchemist, his aspirations after great discoveries must often have been encouraged by the singular phenomena which he encountered, and the startling results at which he arrived. The most ignorant compounder of simples could hardly fail to witness the almost magical transformations hemical bodies; and every new product which he obtained must have

added to the probability that the tempting doublet of gold and silver would be thrown from the dice-box with which he gambled. When any of the precious metals were actually obtained from the ores of lead and other minerals, it was not unreasonable to suppose that they had been formed during the process; and men not disposed to speculate might have thus embarked in new adventures to procure a more copious supply, without any insult being offered to sober reason, or any injury inflicted on sound morality.—*Life of Sir Isaac Newton*, vol. ii. pp. 372-3.

Sir David Brewster maintains that the Alchemy of Boyle, Newton, and Locke must not be considered to have been prompted either by the ambition of wealth or of praise, but a love of truth alone, a desire to make new discoveries in chemistry, and a wish to test the extraordinary pretensions of their predecessors and their contemporaries. In so far as Newton's inquiries were limited to the transmutation and multiplication of metals, and even to the discovery of the Universal Tincture, we may find some apology for his researches; but we cannot understand how a mind of such power, and so nobly occupied with the abstractions of geometry and the study of the material world, could stoop to be even the copyist of the most contemptible alchemical poetry, and the annotator of a work the obvious production of a fool and a knave.

Leibnitz, Newton's great rival, was also an alchemist; he joined a society of Rosicrucians at Nuremberg, in the pursuit of the Philosopher's Stone. Leibnitz, however, soon renounced his faith in the mystic art; and there is reason to believe, from one of Newton's letters to Locke, that he had also learned to have but little confidence even in the humbler department of the multiplication of metals.*

VAN HELMONT.

Van Helmont worked most ingeniously in the illustration of Alchemy. When Thales had asserted that water was the first of the elements, and that all the visible creation deduced therefrom its origin, it was said in subsequent ages that the planets, according to their own power and their position in fiery, airy, earthy, and watery signs, so acted upon the fluid mass as to produce that quaternion of elements alone, for a long time, admitted by the philosophers:

* When Locke, as one of the executors of Boyle, was about to publish some of his works, Newton wished him to insert the second and third part of one of Boyle's recipes (the first part of which was to obtain "a mercury that would grow hot with gold"), and which Boyle had communicated to him on condition that they should be published after his death. In making this request, Newton desired that it might not be known that it came through his hands." And he adds: "One of them seems to be a considerable experiment, and may prove good use in medicine in analysing bodies. The other is only a knack. In dissuading you from too hasty a trial of this recipe, I have forborne to say any thing against multiplication in general, because you seem persuaded of it, though there is one argument against it which I could never find an answer to, and which if you will let me have your opinion about it, I will send you in my next." (Letter to Locke, Aug. 2, 1692: *Lord King's Life of Locke*, vol. i.)

Air, and ye elements, the oldest birth
 Of Nature's womb, that in quaternion run,
 Perpetual circle, multifiform, and mix
 And nourish all things.

Milton.

Van Helmont took up this doctrine of Thales, and attempted to prove its correctness by the following experiment: He took a vessel of earth, carefully levigated, and which weighed exactly two hundred pounds. In this he planted a willow, which weighed five pounds. After the lapse of five years, he took the willow from the earth, and weighed it: it had increased to 164 pounds. He also weighed the earth, which had not increased or decreased in weight. From this he argued, that, as he had carefully prevented any thing from being put to the earth but water, and as the earth in the vessel had lost nothing of its quantity,—the wood, the sap, and all the materials of which the tree might be found by analysis to consist, were all composed of water alone. "Hence," said he, "we need nothing but water to form gold; since, by means of this element, we make a tree, a plant, an animal, even an entire world." The reasoning used by Van Helmont must have been unanswerable in his day, for the solution of the phenomenon required a far more advanced state of chemical science than at that time existed. Van Helmont pretended to have once performed with success the process of transmuting quicksilver, and was, in consequence, invited by Rudolph II. to fix his residence at the Court of Vienna.

With a much greater show of reason he noticed some of the properties of, what he calls, gas sylvestre, or carbonic-acid gas: he observes that it is invisible, but that it was fixed in bodies; and he attributes the phenomena of the Grotto del Cane to its presence.

GLAUBER AND BRANDT.

Glauber, the laborious German chemist, who died in 1688, although an alchemist and believer in the Universal Medicine, greatly improved many chemical processes. He discovered the salt which yet bears his name; he greatly improved the manufacture of nitric and muriatic acids; and in his work is a rude representation of the implement now known as Woulfe's Apparatus. To Glauber we also owe the first production of pyroligneous acid; the distillation of ammonia from bones, and its conversion into sal ammoniac by the addition of muriatic acid; the preparation of sulphate of ammonia, and its conversion into uriate by the agency of common salt; and the production of phosphate of copper by acting upon green rust of copper with phuric acid.

To Brandt, the alchemist, of Hamburg, we owe the discovery, in 1669, of the elementary non-metallic body phos-

phorus, which he procured from urine, while searching for some substance capable of transmuting silver into gold. He kept the mode of preparation for a long time secret; but as he could not conceal the fact of its being obtained from urine, Kunckel, another alchemical adept, tried to obtain it from the same source, and succeeded. Kunckel also left a valuable treatise on Glass-making.

GEOFFROI AND HOMBERG.

In the eighteenth century some operations were made which for a while revived the hopes of hermetic students, and led them to consider "the great secret as almost within their grasp;" and these bright hopes were encouraged by Geoffroi and Homberg, the latter a seeker, and, as he himself once thought, no unsuccessful one, of the Philosopher's Stone. About the year 1735, there was established at Paris a manufactory with the object of changing iron into copper; and, as it was indubitable that a quantity of copper was actually sent out of this manufactory, and it was equally certain that nothing but iron and a certain vitriolic solution was used, this was believed to be but the first step of a series of transmutations; since he who began by transmuting iron into copper would doubtless soon transmute that copper into silver, and the silver into gold. Much capital was invested in the Paris scheme; but the manager of the works soon disappeared, leaving behind him only a small quantity of iron, and some blue vitriol, or sulphate of copper. The mystery was now cleared up; the copper contained in the vitriol had been precipitated upon the iron, which had been dissolved in turn, and thus the appearance of transformation had been effected. A short time before this, M. Geoffroi had declared that by a certain union of clay and linseed-oil iron had been formed. The Alchemists of course rejoiced: if it were possible, even without a metal, to make iron, easier was it to make gold by means of an inferior metal. But M. Geoffroi had overlooked the fact that iron already existed in the clay as a colouring oxide, and he candidly acknowledged his error. Five years previously, M. Homberg had declared that he had not transmuted lead or any inferior substance into gold, but the change of gold itself into glass. Still, no other person was able to produce the same results. Among those who attempted was the Landgrave of Hesse Cassel, who had apparatus made for the purpose; but neither he nor any one who tried succeeded, save Homberg himself.

BERGMANN AND THE ALCHEMISTS.

Bergmann, the distinguished chemist, born in West Gothland in 1735, in his *History of Chemistry during the Middl*

Ages, gives a number of cases in which gold has been supposed to be formed by the use of the Philosopher's Stone. They were unquestionably the result of fraud, by secretly introducing into the crucible gold, which they pretended to have obtained by transmutation. But Bergmann observes respecting the probability and possibility of transmutation, that although most of the narratives are deceptive, and many uncertain, some bear such character and testimony, that, unless we reject all historical evidence, we must allow them entitled to confidence. "For, doubtless," he adds, "if a person who has no faith in the changes of alchemistry should obtain by chance a small piece of the Philosopher's Stone, and, on making the experiment alone in his closet, procure a quantity of gold heavier than the Stone, will it not be difficult to explain in what manner he was deceived?" Before the difficulty is required to be explained, it must, however, be placed on incontestable evidence.

DR. PRICE THE ALCHEMIST.

Towards the close of the last century, Dr. James Price, a medical practitioner in the neighbourhood of Guildford, Surrey, acquired some notoriety by an alleged discovery of methods of transmuting mercury into gold or silver. He had been a student of Oriel College, Oxford, where he obtained the degree of Bachelor of Physic. In 1782 he published an account of his Experiments on Mercury, Silver, and Gold, performed at Guildford, in that year, before Lord King and others, to whom he appealed as eye-witnesses of his wonder-working power. It seems that mercury being put into a crucible, and heated in the fire with other ingredients (which had been shown to contain no gold), he added a red powder; the crucible was again heated, and being suffered to cool, amongst its contents, on examination, was found a globule of pure gold. By a similar process, with a white powder, he produced a globule of silver. The character of the witnesses of these manifestations gave credit and celebrity for a time to Price, who was honoured by the University with the degree of Doctor of Physic; and he was also elected a Fellow of the Royal Society. Dr. Price had now placed himself in a perilous position; for persons acquainted with the history of alchemy must have conjectured how the gold and silver in his experiments might have been procured without any transmutation of mercury or any other substance. The Royal Society authoritatively required that the pretensions of the new associate should be properly sifted, and his claim as a discoverer be clearly established, or his character as an impostor exposed. A repetition of the Doctor's experiments before a committee of the Royal Society was commanded on pain of expulsion; when the unfortunate man,

rather than submit to the ordeal, took a draught of laurel-water,* and died on July 31, 1783, in his twenty-fifth year.

NINETEENTH CENTURY.

At the beginning of the present century, some persons of eminence in science thought favourably of Alchemy. Professor Robison, writing to James Watt, Feb. 11, 1800, says: "The analysis of alkalies and alkaline earths will presently lead, I think, to the doctrine of a *reciprocal convertibility of all things into all*; . . . and I expect to see alchemy revive, and be as universally studied as ever."^{*}

Sir Walter Scott, in his excellent paper on Astrology and Alchemy in the *Quarterly Review*, 1821, relates that about 1801 an adept lived, or rather starved, in the metropolis, in the person of an editor of an evening journal, who expected to compound the alkahest if he could only keep his materials digested in his lamp-furnace for the space of seven years. The lamp burnt brightly during six years, eleven months, and some odd days besides, and then unluckily it went out. Why it went out the adept never could guess; but he was certain that if the flame could only have burnt to the end of the septenary cycle, his experiment must have succeeded.

PETER WOULFE.*

The last true believer in alchemy, according to Mr. Brande, was Peter Woulfe, the eminent chemist, associated with Woulfe's Apparatus, for condensing gaseous products in water, and a Fellow of the Royal Society. Among his contributions to the *Philosophical Transactions* are "Experiments to show the nature of Aurum Mosaicum."

Woulfe was a tall, thin man; he died in Barnard's Inn, Holborn, in 1805, and his last moments were remarkable. By his desire, his laundress shut up his chambers, and left him, but returned at midnight, when Woulfe was still alive: next morning, however, she found him dead; his countenance was calm and serene, and, apparently, he had not moved from the position in which she had last seen him.—*Curiosities of London*.

Little is known of Woulfe's life. Sir Humphry Davy states that he used to affix written prayers and inscriptions of recommendations of his processes to Providence. His chambers were so filled with furnaces and apparatus that it was difficult to reach his fireside. Dr. Babington told Mr. Brande that he once put down his hat, and never could find it again, such was the confusion of boxes, packages, and parcels that lay about the room. His breakfast-hour was four in the morning; a few of his select friends were occasionally invited, and gained entrance by a secret signal, knocking a certain number of times at the inner door of the chambers. He had long vainly searched for the Elixir, and attri-

* Brande's *Journal of Science*, vol. ix. p. 237.

† Muirhead's *Origin and Progress of the Mechanical Inventions of James Watt*, vol. ii.

buted his repeated failures to the want of due preparation by pious and charitable acts. Whenever he wished to break an acquaintance or felt himself offended, he resented the supposed injuries by sending a present to the offender, and never seeing him afterwards : these presents sometimes consisted of an expensive chemical product or preparation. He had a heroic remedy for illness, which was a journey to Edinburgh and back by the mail-coach ; and a cold taken on one of these expeditions terminated in inflammation of the lungs, of which he died.

KELLERMAN.

In 1825 Sir Richard Phillips visited "an alchemist" named Kellerman, at the village of Lilley, between Luton and Hitchin. He was believed by some of his neighbours to have discovered the Philosopher's Stone and the Universal Solvent.

His room was a realisation of the well-known picture of Tenier's Alchemist. The floor was strewn with retorts, crucibles, alembics, jars, and bottles of various shapes, intermingled with old books.

Sir Richard proceeds to relate :

He gave me a history of his studies, mentioned some men in London whom I happened to know, and who, he alleged, had assured him that they had made gold. That having, in consequence, examined the works of the ancient alchemists, and discovered the key which they had studiously concealed from the multitude, he had pursued their system under the influence of new lights ; and, after suffering numerous disappointments, owing to the ambiguity with which they describe their processes, he had at length happily succeeded ; had made gold, and could make as much more as he pleased, even to the extent of paying off the National Debt in the coin of the realm.

Kellerman then enlarged upon the merits of the ancient alchemists, and on the blunders and impertinent assumptions of modern chemists. He quoted Roger and Lord Bacon, Paracelsus, Boyle, Boerhaave, Woulfe, and others, to justify his pursuits. As to the term Philosopher's Stone, he alleged that it was a mere figure to deceive the vulgar. He appeared to give full credit to the silly story of Dee's finding the Elixir at Glastonbury, by means of which, as he said, Kelly for a length of time supported himself in princely splendour. Kellerman added, that he had discovered the *blacker than black* of Apollonius Tyanus : it was itself "the powder of projection for producing gold."

It further appeared that he had lived in the premises at Lilley for twenty-three years, during fourteen of which he had pursued his alchemical studies with unremitting ardour ; keeping eight assistants for superintending his crucibles, two at a time, relieving each other every six hours : that he had exposed some preparations to intense heat for many months at a time ; but that all except one crucible had burst, and that, Kellerman said, contained the true "blacker than black." One of his assistants, however, protested that no gold had ever been found, and that no mercury had ever been fixed ; for he was quite sure Kellerman could not have concealed it from his assistants ; while, on the contrary they witnessed his severe disappointment at the result of his elaborate experiments.*

Personal Tour through the United Kingdom, Part I., Nov. 1828. See "Secret Alchemists," *Things not generally Known*, p. 116; and "The Philosopher's Popular Errors Explained," p. 144.

DIALECT OF THE ALCHEMISTS.

The literal interpretation of the Hermetic treatises, and what may be termed their "Shibboleth," has probably led to Alchemy being overwhelmed with the reproaches of the modern world. Sometimes, in their dialect, man was designated as the Stone, antimony, lead, zinc, or arsenic; but they point to the means of his perfection, as animated mercury, the serpent, the green lion, shark, water, or virgin's milk. Figuier, speaking of this element, says that none of the alchemists have ever discovered it. The spirit of fire, transmuting all things, the salt of tartar, the spirit of wine driven to the centre by cold, and the essential salt of vipers, remain mysteries in the Hermetic dialects. Artepheus wrote on antimony, but was illegibly obscure; and spoke of the salt of the sun and moon to be made homogeneous with other imperfect bodies of argent vive,—the water of life, azoth, and the true tincture. Basil Valentine adds the unicorn's horn, "the aguish magnetified needle."

If Bishop Berkeley knew what *Alcahest* meant, and if Kunkel was wrong in his application of a physical law to demonstrate its impossibility, it may be safely affirmed that no one has ever reduced to common sense the works of Geber the Arabian. Of course, the language of the Adepts was not designed for ordinary readers, being expressly designated as the magic language, and the language of angels. This, however, does not prove it to have contained any philosophy more practical than that which occupied itself in studying the secret of transmutation. What was of a mixed nature, between fixed and not fixed, and partook of a sulphurazurine? What was a raw, cooling, feminine fire? or the lustral water that cleansed the earth? Pure gold, violet, citrine, virgin's milk, purple, and transcendent redness, prove that, as Erynæus says, "this art is very cabalistical."

Grew thus points to the importance of gold in the art: "Every alchemist knows that gold will endure a vehement fire for a long time without any change; and after it has been divided by corrosive liquors into invisible parts, yet may presently be precipitated so as to appear in its own form."*

The students of the art were, however, told that under its enigmatical language was concealed the direction for a very easy and simple process. Raymond Lully remarks: "In the art of our magistrery nothing is hid by the philosophers except the secret of the art, which it is not lawful for any man to re-

* Suidas maintains that the Golden Fleece, which Jason and the Argonauts (after a voyage through the Black Sea to Colchis) took, together with Medea, is not what the poets represent, but a treatise written on skins, teaching how gold might be prepared by chemistry; 'probably it was called *golden* by those who lived at that time on account of its great importance.'

veal, and which, if it were done, he should be cursed, and should incur the indignation of the Lord, and should die of an apoplexy." The conclusion of Chaucer's "Chanon Yeoman's Tale" is much to the same purpose, except that the poet advises, since there is so great a secret, which is so by the especial providence of God, man shall not attempt to discover it. The Alchemists, on the contrary, say that it is only intended to be concealed from the profane; and that if any man by long study do attain to its knowledge, then to him it is revealed by the divine favour; and this mixture of religion and Alchemy will be found pervading every treatise on the subject. Hermes Trismegistus, in one of the treatises ascribed to him, directs the adept to catch the flying bird, and to drown it, so that it fly no more; by which is meant the fixation of quicksilver by a combination with gold. It is after this to be subjected to the action of *aqua regia*, by which its soul will be dissipated, and it will be united to the red eagle (muriate of gold). This is enigmatical, says Mr. Christmas, but it promises something. On the other hand, Elias Ashmole, who, if not himself a working alchemist, called the adept Backhouse "father," and studied Hebrew that he might fully illustrate the Hermetic philosophy, and the Philosopher's Stone,—has, in his *Theatrum Chemicum Britannicum*, preserved this fragment of banter :

I asked Philosophy how I should
Have of her the thing I would.
She answered me, when I was able
To make the water malleable;
Or else the way if I could find
To measure out a yard of wind;
Then shalt thou have thine own desire
When thou canst weigh an ounce of fire:
Unless that thou canst do these three,
Content thyself thou gett'st not me.

Mr. Christmas describes a manuscript of the seventeenth century, in the Cambridge University Library, illustrated by coloured drawings of dragons, eagles, crucibles, and alembics; and speaking of the formation of precious stones, and implying the discovery of the second great object of the alchemist, viz. the Universal Solvent, or the Alkahest; the absurdity of which notion was exposed by Lavoisier. He inquired, *if the solvent were universal*, what vessel would hold it. The idea afforded only this one absurdity, that of supposing the solvent universal as to its effects. The experiments of Becquerel in France, and of Crosse in England, amply demonstrate that the operations of nature in the formation of minerals may, on a small scale, be performed by the electrician. The Alchemists did not expect to make diamonds, or even to make gold, out of that which was an essentially different substance. The baser metal was to

be intrinsically purified; that terreous matter which caused it to differ from gold was to be "burnt and purged away," the fragments of the diamond were to be dissolved and reunited, or the ordinary flint was to be treated like the baser metal. The Ms. above quoted assumes also that the three great objects of the philosopher's search, namely, the transmuting agent, the universal solvent, and the universal remedy,—in other words, the Philosopher's Stone, the Alkahest, and the Elixir of Life,—were essentially the same body, causing by its purifying power the base and imperfect substance to cast aside its impurities, and exhibit itself in the most simple and perfect state, bringing back health and youth to the shattered constitution, and when pure, dissolving and decomposing all the bodies in order to exhibit them in a renovated and more complete form.*

The phenomena of life, death, and resurrection were illustrated by the language of Alchemy, the science of the period :

We poor mortals (says Basil Valentine) are, for our sins' here, by means of that death which we have well deserved, pickled in the earthly, that is, the kingdom of earth, till in process of time we become putrid and rot; and then are once more awakened, clarified, and sublimed by virtue of the heavenly fire and heat, even to the celestial sublimation and elevation; for all our dross, sins, and impurities are sundered from us.

Luther, in his *Canonica*, praises Alchemy, "by reason of the glorious and fair resemblances which it has to the raising of the dead; for even as fire from each kind of thing doth extract that which is best, and doth sunder it from the bad, and thus doth carry the spirit itself upward, so that it shall have the upper place, whereas matter, like unto a dead body, doth remain below lying on the earth, so also will God, at the last day, sunder the godless and unrighteous from the righteous and godly. The righteous will ascend to heaven, but the unrighteous will abide below in hell.

In old diaries we find occasionally curious entries of the *arcana*. Aubrey relates that there lived at Wilton, in his day, one Mr. Boston, a Salisbury man, who was a great chemist, and did great cures by his art. But after long search for the Philosopher's Stone, he died at Wilton, having spent his estate. "After his death, they found in his laboratory there two or three baskets of *egge shelles*, which I remember Geber saith is a principall ingredient of that Stone."

The delusive character of the art has been cleverly epigrammatised. Libavius, whose name is more familiar as a chemist than as an adept, has this "rime" of *Alchemy* :

Alchymia est ars sine arte,
Cujus scire est pars cum parte,
Medium est strenue mentiri,
Finis mendicamentum iri.

The name of Alchemy has been applied to the modification of brass, supposed to have been occasionally formed by the Alchemist. Fletcher, in his *Purple Island*, c. vii., has

Such were his arms, false gold, true alchemie.

Milton uses it for trumpet-metal :

Four speedy cherubims

Put to their mouths the sounding alchemy.

Paradise Lost, ii. 517.

Minshull (*Essay*, p. 23) mentions "rings and chaines bought at St. Martin's,* that weare faire for a little time, but shortly after will prove alchemy, or rather pure copper."

The word alchemy was corrupted into *Occamy* or *Ockamy*, when it was applied to an imitation of silver. In Nash's *Lenten Stuffle* we read, "Pilchards are but counterfeit to her-rings, as copper to gold, or ockamie to silver;" Steele, in the *Guardian*, No. 26, speaks of an *occamy spoon*; and the term is not yet quite disused among some classes. Johnson describes it as a "kind of mixed metal used for spoons and kitchen utensils."

Bacon, in his *Physical Remains*, however, distinguishes it thus: "white alchemy is made of pan-brass, one pound, and arsenicum, three ounces; or alchemy is made of copper and auripigmentum."

Alchemy was the science of this period; and hence, by degrees, alchemistical forms of expression for terrestrial processes passed into the language of ordinary life. The words *spirit of wine*, *spirit of salt*, *spirit of nitre*, and so forth, sufficiently bespeak a general belief in supernatural or occult agencies.

Ebenezer Sibly has published two quarto volumes on medico-astrological science; and speaks mysteriously, if not profoundly also, of alchemy; his reanimating Solar Tincture and his Lunar Tincture speak by their titles (*Christmas*). Of the same fraternity is Daffy's Elixir, from the *Elixir Vitæ*.

The chemistry of the Indians, embracing alchemistic arts, is called *rasdyana* (*rasa*, juice or fluid, also quicksilver; and *ayâna*, course or process), and forms, according to Wilson, the seventh division of the *âyur-Veda*, "the science of life, or the prolongation of life." (Royle, *Hindoo Medicine*.)

Gibbon, speaking of alchemy, says, that, "congenial to the arice of the human heart, it was studied in China, as in rope, with equal eagerness and with equal success. The kness of the middle ages ensured a favourable reception to y new tale of wonder; and the revival of learning gave

St. Martin's-le-Grand was, until a very late period, noted for its manufac- of counterfeit ware, as latten and copper articles, St. Martin's copper-lace, camy ware. In the adjoining Aldersgate and Cripplegate are, to this day, incipal refiners and workers of precious metals.

new vigour to hope, and suggested more specious arts of deception. Philosophy, with the aid of experience, has at length banished the study of alchemy; and the present age, however desirous of riches, is content to seek them by the humbler means of commerce and industry."—*Decline and Fall*, vol. ii.

THE GOLDEN CHAIN OF HOMER.—THE HERMETIC OR MERCURIAL CHAIN.

Upon this famous wonder of the Ancients, we find in *Notes and Queries*, Second Series, Nos. 56, 57, and 58, by an anonymous Correspondent, a paper of extraordinary interest, the leading points of which we have condensed, selecting those which the more directly relate to Alchemy.

There exists a very curious book of Hermetic lore, entitled *Aurea Catena Homeri* (or, the Golden Chain of Homer), originally published in German, and translated into Latin by Dr. Favrat; for the loan of which when in Ms. 100 dollars were sometimes given, or for information concerning it. The author, who lived in the 17th century, was one Fuldang Leopold Codrus, who describes himself as a poor, persecuted ploughman and peasant.

The work may be in few words characterised as a treatise on the doctrine of a Graduated Chain of Nature, or Chain of Being, in two parts—(1) *Of the Generation of Things*, (2) *Of the Corruption of Things, and their Anatomy*; the author following the Egyptians and most ancient usages in regarding Nature as a Series of Rings, or Revolving Circles, forming a vast chain, which links the Deity with his humblest creatures. However, Codrus deals not so much with the Scale of Creatures as with the Protean Chain of Metamorphoses and Transmutations, which unites in one the Dyads or Bipolarities of Life and Death, Generation and Corruption, Corruption and Regeneration, Coagulation and Dissolution, Evaporation and Condensation, Volatilisation and Fixation, &c. Or, in the author's words, "How Nature herself dissolves and coagulates, resolves and regenerates. For what Nature makes, and by what means she makes it, through the very same means she destroys all again. Thus every thing has its Coagulator and Resolver, its Life and Death, within its own self, through which it is produced and sustained, and again broken up and destroyed. For from diversities of operation and of modes of operation proceeds a different working of effect."

In Part II. we have a curious passage on Transmutation, or expansion of the idea in the *Religio Medici*, as follows: "'All flesh is grass' is not only metaphorically but literally true; for all these creatures we behold are but the herbs of the field

digested into flesh in them, or more remotely carnified in ourselves."—*Religio Medici*.

Coleridge, too, in the conclusion of his *Aids*, speaking of the magic metamorphoses wrought by the occult power of *Assimilation*, has this eloquent passage :

The germinal power of the planet transmutes the fixed air and the elementary base of water into grass or leaves ; and on these the organic principle in the ox or the elephant exercises an alchemy still more stupendous. As the unseen agency weaves its magic eddies, the foliage becomes indifferently the bone and its marrow, the pulpy brain, or the solid ivory, &c.—*Aids*, vol. i.*

A parallel to this doctrine may be found among the Burmese, who appropriately call the world "Logha," which signifies *alternate Destruction and Reproduction*. In Ovid (*Met.* lib. xv.) we have a good specimen of the old Egyptian philosophy on this head, as taught by Pythagoras.

The best and shortest summary that could be given of the contents of the *Aurea Catena Homeri* may be attained by quoting the following passage from an old Hermetic treatise, called *The Secret of Secrets*, ascribed to a certain King Kalid :—

We have taught how a body is to be changed into a spirit, and again how the spirit is to be turned into a body, namely, how the fixed is made volatile, and the volatile fixed again : how the earth is turned into water and air, and the air into fire, and the fire into earth again : then the earth into fire, and the fire into air, and the air into water, and the water again into earth. Now the earth, which was of the nature of fire, is brought to the nature of a quintessence. Thus we have taught the ways of transmuting performed through heat and moisture ; making out of a dry a moist thing, and out of a moist a dry one : otherwise natures which are of several properties or families could not be brought to one uniform thing, if (unless ?) the one should be turned into the other's nature. And this is the perfection according to the advice of the philosopher. Ascend from the earth into heaven, and descend from heaven to the earth ; to the intent to make the body which is earth into a spirit which is subtil, and then to reduce that spirit into a body again, which is gross : changing one element into another, as earth into water, water into air, air into fire ; and that into a more subtil nature and quintessence. Thus have you accomplished the treasures of the whole world.†

The *Aurea Catena Homeri* derives its name from the celebrated passage at the beginning of the 8th book of Homer's *Iliad* (Cowper's translation), commencing thus :

Let ye down the *Golden Chain*
From Heaven, and pull at its inferior links
Both Goddesses and Gods.

The allusions to this Homeric Chain in old writers are very

* Coleridge, possibly, had in mind a passage in Herder's *Ideen*, book v. c. 3.

† These Transmutations remind one of the nursery-tale of *The Old Woman bringing her Kid to Market*, which Mr. Halliwell, in his work on Nursery thymes, traces to an allegoric-rabbinic parable of Transmutation.

numerous. In *Paradise Lost* Chaos observes in his speech to Satan,

Now lately Heaven and Earth, another World,
Hung o'er my realm, link'd in a *Golden Chain*
To that side Heaven from whence your legions fell.

Book ii. l. 1004.

And in the same book, l. 1050, Milton again alludes to it :

And fast by, hanging in a *Golden Chain*
This pendent World, in bigness as a Star
Of smallest magnitude, close by the Moon.

The *Golden Chain* of Sympathy, this occult, all-pervading, all-connecting influence,* is the source of all Magic, and is called by a variety of names—such as, *The Vital Magnetical Series*, *Jacob's Ladder*, *Anima Mundi*, *Mercurius Philosophorum*, *the Magician's Fire*, &c. The Chain, as we find it in the most eminent philosophers, may be thus shortly concatenated: *Omnia et Uno*, *Omnia in Uno*, *Omnia ad Unum*, *Omnia per Medium*, *et Omnia in Omnibus*.

“Every thing,” says Plato (*Protag.* 260), “resembles every other thing in some respect.”

Thus, too, Hippocrates: “There is one conflux, one conspiracy, and all things sympathise with all.”

And Macrobius :

There will be found, on a closer inspection, from the Supreme God down to the lowest dregs of things, one uninterrupted chain of connection, mutually binding them together.

Oswald Crollius, the Paracelsist, observes :

Plato's Rings and *Homer's Chains* are nothing but a Divine Series and Order serving Providence, a gradual and concatenate *Sympathy of things*. This visible and invisible Fellowship of Nature is that *Golden Chain* so much commended, this is the marriage of heaven and riches, these are *Plato's Rings*, this is that dark and close Philosophy so hard to be known in the most inward and secret parts of Nature, for the gaining whereof Democritus, Pythagoras, Plato, Apollonius, &c., have travelled to the Brachmans and Gymnosophists in the Indies, and to Hermes his pillars in Egypt. This was that which the most ancient Philosophers studied, &c.—*The Admonitory Preface*, translated by Pinnell, 1657.

Sir Thomas Browne remarks :

In a wise supputation, all things begin and end in the Almighty. There is a nearer way to Heaven than *Homer's Chain*: an easy logic may conjoin a heaven and earth in one argument, and, with less than a sorites, resolve all things to God. For though we christen effect by their most sensible and nearest causes, yet is God the true and inflexible cause of all; whose concurrence, though it be general, yet doth subdivide itself into the particular actions of every thing, and is th

* “That Magnetic Chain which is extended *a non gradu ad non gradum*: the Ladder of Celsus and of Zoroaster which reaches from Tartarus to the high Heaven.”—*Suggestive Inquiry into the Hermetic Mystery*, p. 338.

Spirit by which each singular essence not only subsists, but performs its operations.—*Religio Medici*.

Sir John Davies, in his noble poem on the Immortality of the Soul, thus speaks of "God's Eternal Law :"

Could Eve's weak hand, extended to the tree,
In sunder rend that *Adamantine Chain*,
Whose *Golden Links*, effects and causes be;
And which to God's own chair doth fixed remain.
Oh, could we see how cause from cause doth spring !
How mutually they linked and folded are !
And hear how oft one disagreeing string
The harmony doth rather make than mar !

The following passage is from a Treatise entitled *Schola et Scala Naturæ* :

Nature doth not lead thee towards GOD by a far-fetched and winding compass, but in a short and straight line. The *Sun* waits upon the *Rain*, the *Rain* upon the *Grass*, the *Grass* serves the *Cattel*, the *Cattel* serve thee ; and if thou serve God, then thou makest good the highest Link in the Golden Chain, whereby Heaven is joined to Earth ; then thou standest where thou oughtest to stand, in the uppermost round of the Divine Ladder, next to the Most High : then thou approvest thyself to be indeed what thou wert designed by God to be, the High-Priest and Orator of the Universe ; because thou alone, amongst all the creatures here below, art endowed with understanding to know Him, and speech to express thy knowledge of Him in thy praises and prayers to Him.

The mystic Chain of Homer is called "golden" not merely as an epithet of eminence, but the term has an occult and peculiarly appropriate significance, especially in Hermetic works. In the first place, Gold was at once a Symbol of God and a Symbol of the Sun.

The Mystical Philosophers and Alchemists, generally speaking, regarded gold as a concretion or concentration of Light, or rather Fire. Van Helmont calls the Sun "a living and spiritual Gold, which (Gold) is a meer Fire, and beyond all, thoroughly refined Gold." Barton, speaking of "the properties of *Elemental Fire* or *Æther*," quotes "an eminent philosopher and divine" to the same purpose : "Fire is the universal fountain of life, order, distinction, stability, and beauty of the universe. It is not only in the Sun and other heavenly bodies, but it makes part of every lump of matter upon and in our globe. . . . Gold is no more than Mercury with abundance of Light or Fire in it, as appears from an experiment. . . . So quick in its motions, so subtle and penetrating in its nature, so extensive in its effects, it seemeth no other than the *Vegetative Soul and Vital Spirit* of the world."—*The Analogy of Divine Wisdom*, 1750.*

* See also J. Webster's *Metallographia* ; or, a History of Metals ; also the Handling and Showing of their Vegetability, and the Discussion of the most difficult Questions belonging to Mystical Chemistry, as of the Philosophers' Gold, their Mercury, the Liqueur Alkahest, Aurum Potabile, and such like. 1761.

Moreover, Philo says :

Those who praise Gold dwell on two especial points as most particularly important and excellent : one, that it does not receive poison ; the other, that it can be beaten out or melted into the thinnest possible plates while still remaining unbroken. Therefore, it is very naturally taken as *an emblem of that Greater Nature*, which being extended and diffused every where, so as to penetrate in every direction, is wholly full of every thing, and also connects all other things with the most admirable harmony.—*On the Hieir of Divine Things.*

Oswald Crollius says to the same effect :

Nature is that medium which by an harmonical consent joyneth the lowest things to the highest, and sometimes is called Animall, sometimes Vegetable, sometimes Minerall, according to the diversity of the subject or receptacle. Those who diligently seek out the Hermetic Phylosophy and the marvellous works of God, know that *that* same Spirit and minerall Nature which produceth Gold in the bowells of the earth is also in Man. That Spirit in Gold is the same with the Generating Spirit of all creatures, and is the same and onely Generative Nature, diffused through all things. This Spirit now hath assumed a Naturall body : It is that which first moveth and ruleth Nature in all naturall things, it preserveth all things, and all inferior things by a kind of harmonical consent are governed by it. Albertus Magnus, in his Book of Mineralls, saith that gold may be found every where. There is not, saith he, that thing elementated of the Four Elements in which gold naturally may not be found in the last subtiliation thereof. And therefore the Phylosophers say that the Matter of their Mystery may be had every where, because it consisteth in every Elementated thing.

Gold has been always mystically connected with the Divine and Heavenly. Thus the Seven Heavens of the Hindoos (included with the natural heavens and the earth into one system) are surrounded by a broad circumference of gold. This Golden Circle is the symbol of the Sun's sphere, and understood spiritually, it is the Divine Love, surrounding and containing all. The Wedding Ring represents the same thing in miniature. Thus, too, with the Jews, among the sacred vestments of the High-Priest (which hieroglyphically represented the Universe), the Golden Breastplate was fastened to the Ephod by Golden Rings and Golden Chains ; and the Ephod itself was girded on the High-Priest with a gorgeous cincture called the Golden Circle.

The Golden Chain of Homer is sometimes called the Hermetic or Mercurial Chain, from Hermes, or Mercury, among the Ancients being the personification of that pure Æther or invisible Fire which ensouls or concatenates all things in Nature : that Intellectual and Winged Spirit which illuminates, vivifies, and flashes through all things : that Universal Being or Plastic Spirit in Nature : that mysterious, all-pervading, all-constraining Magnetic Influence, which being itself One, unites in

One the Protean Forms of the Universe through which it passes,
—that Informing, Unifying Spirit, of which Virgil speaks :—

Principio cœlum, ac terras, camposque liquentes,
Lucentemque Globum Lunæ, Titaniaque astra,
Spiritus intus alit ; totamque infusa per artus
Meus agitat molem, et magno se corpore miscet.—Æn. lib. vi.

Know first that heaven and earth's compacted frame,
And flowing waters, and the starry flame,
And both the radiant lights, one common soul
Inspires and feeds, and animates the whole.
This active mind, infus'd through all the space,
Unites and mingles with the mighty mass.

Dryden.

Here, then, we have the *Mystic Fire* of the Eastern Sages, the *Astral Spirit* in Man of Paracelsus, the *Anima Mundi*, the *Golden Chain* of Homer, the *Mercury* of the Philosophers, the *Gold* of the Alchemists, the *Magical Quintessence*, for according to the old maxim, "All is in Mercury which the Wise men seek."

The remainder of the paper relates to the doctrine popularly known as "The Chain of Being."

In conclusion, we may observe, that within the last ten years has been printed in England a volume of considerable extent, entitled *A Suggestive Inquiry into the Hermetic Mystery*, London, T. Saunders, 1850. This work, which the Correspondent of *Notes and Queries* describes as "a learned and valuable book," is by a lady (anonymous), and has been suppressed by the author.

By this circumstance we are reminded of a concealment of alchemical practices and opinions, some thirty years since, when it came to our knowledge that a man of wealth and position in the metropolis, an adept of Alchemy, was held in *terrorem* by an unprincipled person, who extorted from him considerable sums of money under a threat of exposure.

Nevertheless, Alchemy has, in the present day, its prophetic advocates, who predict what may be considered a return to its strangest belief.

The nineteenth century has not yet passed away ; and Dr. Christopher Girtanner, an eminent professor of Göttingen, has prophesied, in a memoir on Azote, in the *Annales de Chimie*, No. 100, that it will give birth to the *Transmutation of Metals* ! "In the nineteenth century," says the Professor, "the transmutation of metals will be generally known and practised. Every chemist and every artist will make gold : kitchen utensils will be of silver, and even gold, which will contribute more than any thing else to prolong life, poisoned at present by the oxides of copper, lead, and iron, which we daily swallow with our food."

ALCHEMICAL EXPERIMENTS ON THE TRANSMUTATION OF METALS.

In 1857, Dr. J. W. Draper, of New York, communicated to the *London Philosophical Magazine* the following remarkable and suggestive paper : " No one who has used a Tithonometer (for measuring the chemical action of light) can have failed to notice the disturbing effects of minute quantities of extraneous gases mingled with chlorine on photo-chemical induction. My attention has been directed to that subject in its more general aspect ; and I will ingenuously confess that I have made several attempts at the transmutation of metals, on the principle of compelling them, by the aid of solar light, to be disengaged from states of combination in the midst of resisting or disturbing media.

The following is a description of these *alchemical attempts*. In the focus of a burning-lens twelve inches in diameter, was placed a glass flask two inches in diameter, containing nitric acid diluted with its own volume of water. Into the nitric acid were poured alternately small quantities of a solution of nitrate of silver and of hydrochloric acid, the object being to cause the chloride of silver to form in a minutely divided state, so as to produce a milky fluid, into the interior of which the brilliant convergent cone might pass, and the currents generated in the flask by the heat might drift all the chloride successively through the light. The chloride, if otherwise exposed to the sun, merely blackens upon the surface, the interior parts undergoing no change : this difficulty I hoped, therefore, to avoid. The burning-glass promptly brings on a decomposition of the salt, evolving, on the one hand, chlorine, and disengaging a metal on the other. In one experiment the exposure lasted from 11 a.m. to 1 p.m. ; it was therefore equal to a continuous mid-day sun of seventy-two hours. The metal was disengaged very well. But what is it ? It cannot be silver, since nitric acid has no action upon it. It burnishes in an agate mortar, but its reflection is not like the reflection of silver ; it is yellower. *The light must therefore have so transmuted the original silver* as to enable it to exist in the presence of nitric acid. In 1837, I published some experiments on the nature of this decomposition in the *Journal of the Franklin Institute*.

Though this experiment, and several modifications of it, which I might relate, fail to establish any permanent change in the metal under trial, in the sense of an actual transmutation, it does not follow that we should despair of final success. It is not likely that nature should have made fifty elementary substances of a metallic form, many of them so closely resembling one another as to be with difficulty distinguished : more-

over, chlorine and other elementary substances can be changed by the influence of sun-light, in some respects permanently ; and if silver has not been thus far transmuted into a more noble metal, as platinum and gold, it has at all events been transmuted into *something which is not silver*. Those who will reflect a little on the matter cannot fail to observe that the sun's rays possess many of the powers once fabulously imputed to the Powder of Projection and the Philosopher's Stone."

ALCHEMY AND ASTROLOGY.

Rightly to appreciate and judge of the true nature of Alchemy, we must remember, that till the sixteenth century the earth was regarded as the centre of the universe, and that the life and destiny of men were believed to stand in the closest relation to the motions of the heavenly bodies. The universe was a vast whole, an organism, the members of which stood in an uninterrupted relation of reciprocal influence. "From all the ends of heaven the creative forces radiate towards the earth, and determine earthly destinies." (*Roger Bacon*.) "When a man," says Paracelsus, "eats a bit of bread, does he not therein consume heaven and earth, and all the heavenly bodies, inasmuch as heaven, by its fertilising rain, the earth by its soil, and the sun by his luminous and heat-giving rays, have all contributed to its production, and all are present in the one substance?" All that happened on earth stood written in starry characters in heaven. All that was thus written in heaven must of necessity happen on earth. Mars, Venus, or some other planet, rules from birth the actions and the fortunes of individual men ; while comets, lawless in their appearance, were the threatening symbols of want and woe to entire nations.—*Liebig*.

TRANSITION FROM ALCHEMY TO CHEMISTRY.

When in the simple notions of the elements of the Alchemists—inflammability (sulphur), fixity (salt), and volatility (mercury)—men came to include the special qualities of inflammable, fixed, and volatile bodies, according as these were observed (oily, fat, earthy mercury ; oily, fat, earthy, easily or difficultly inflammable sulphur ; earthy, fusible, vitreous salt ; inflammable, fat, oily, mercurial earth, &c.), then the significance of the original notion was lost. Becoming too wide and extended, it no longer included observed facts ; and when Boyle searched after the sulphur, mercury, and salt of the Alchemists, these elements no longer existed. The idea was worn out. At a much later period, the notion of a suffocating property was designated by *sulphureous*, the combustion of a fixed body by *calcination* ; that is, these things possessed one property in common with burning sulphur or with limestone (*calx*).

Hence it is no longer possible to give a definition of the terms "acid" and "salt" which shall include all those bodies which are called acids or salts. We have acids which are tasteless, and which do not redden vegetable blues, nor neutralise the alkalis; there are acids of which oxygen is an ingredient, and hydrogen is absent; others which contain hydrogen and no oxygen. The notion of a salt at last became so perverted, that chemists have gone so far as to exclude from the class of true salts, by their definition, common sea-salt, the salt of all salts, to which all others owe their very name.

We can readily see how easily a simple, defined notion becomes undefined by the addition of other notions. In the place of the worn-out ideas, we obtain, when we begin to distinguish, a number of new and more defined and separate ideas. It is even possible that the original idea, all but its name, may be lost; and the time may come when we shall no longer find an acid or a salt, just as we could not find the sulphur and mercury of the Alchemists, when these ideas were no longer necessary to science. Formerly their existence appeared obvious to every man; and they were only sought for when mankind had no further occasion for them.

Humboldt has the following comprehensive view of Alchemy, embodying a note by Kopp:

The alchemistic opinions of the middle ages regarding the composition of metals, and the loss of their brilliancy by combustion in the open air (incineration, calcination), led to a desire of investigating the conditions by which this process was attended, and the changes experienced by the calcined metals, and by the air in contact with them. Cardanus, as early as 1553, had noticed the increase of weight that accompanies the oxidation of lead; and, perfectly in accordance with the idea of the myth of Phlogiston, had attributed it to the escape of a "celestial fiery matter" causing levity; and it was not until eighty years afterwards that Jean Rey, a remarkably skilful experimenter at Bergerac, who had investigated with the greatest care the increase of weight during the calcination of lead, tin, and antimony, arrived at the important conclusion that this increase of weight must be ascribed to the access of the air to the metallic calx. Rey, strictly speaking, only mentions the access of air to the oxides; he did not know that the oxides themselves (which were then called the earthy metals) are only combinations of metals and air. According to him, the air makes "the metallic calx heavier, as sand increases in weight when water hangs about it." The calx is susceptible of being saturated with air. Rey's work, indeed, contains the first approach to the better explanation of a phenomenon whose more complete understanding subsequently exercised a favourable influence in reforming the whole of Chemistry.

Men had now discovered the path which was to lead them to the Chemistry of the present day; and through it to the knowledge of the great cosmical phenomenon, viz. the connection between the oxygen of the atmosphere and vegetable life.—See *Cosmos*, vol. ii. pp. 729, 730.

Alchemy, says Liebig, is one of the three periods of Chem-

istry. In the first, all the powers of men's minds were devoted to acquiring a knowledge of the properties of bodies; it was necessary to discover, observe, and ascertain their peculiarities. This is the alchemistical period. The second embraces the determination of the mutual relations or connections of these properties; and this is the period of phlogistic chemistry. In the third period, in which we now are, we ascertain by weight and measure, and express in numbers, the degree in which the properties of bodies are mutually dependent. The inductive sciences begin with the substance itself; then come just ideas; and lastly, mathematics is called in, and with the aid of numbers completes the work.

ALCHEMY AND ALLOTROPISM.

The importance of Allotropy,* *i. e.* the existence of the same body under more than one form, is thus illustrated by Faraday: "In what does chemical identity consist? in what will the wonderful development of Allotropy end? whether the so-called chemical elements may not be, after all, mere allotropic conditions of fewer universal essences? whether, to renew the speculations of the Alchemists, the metals may be only so many imitations of each other, by the power of science mutually convertible? There was a time when this fundamental doctrine of the Alchemists was opposed to known analogies; *it is now no longer opposed to them, but only some stages beyond their present development.*"

Among the many scientific developments of late origin which tend to bring us back into speculations analogous with those of the Alchemists, is the relation between chlorine, iodine, and bromine. Already have we seen that it is possible for one body to assume, without combination, two distinct phases of manifestation; therefore, such of the so-called elements as are subject to Allotropy are not the unchanging entities they were once assumed to be; and now we find, after our attention has been led in the direction, that the triad of chlorine, bromine, and iodine not only offers a well-marked progression of certain chemical manifestations, but that the same progression is accordant with the numeral exponents of their combining weights. We seem here to have the dawning of a new light, indicative of the mutual convertibility of certain groups of elements, although under conditions which are as yet hidden from our scrutiny.

* The term *Allotropy* is derived from two Greek words, corresponding, as early as they bear literal translation into English, with the expression, *another*, and is employed for the purpose of expressing the existence of certain elements in conditions of manifestation different from those which they usually present, although their chemical composition remains the same.—*Faraday.*

The points or remarkable features of chlorine, iodine, and bromine may be thus sketched. Their dangerous activity when uncombined, their quietude when held in combination, the similarity of their qualities and functions, their gradation in colour and cohesion, and, more than all, the curious law which the consideration of their atomic weights unfolds,—these appear to be the especial features of this interesting triad of non-metallic elements.

Liebig, in his *Familiar Letters*, observes: In what a singular position do these facts place science of the present day, when compared with the opinions of the old philosophers and with Alchemy. The first taught that the properties of bodies were variable; and the Alchemists believed that all metals had in common a fundamental property, and that they were actually convertible. We show that two things, under certain circumstances, are one and the same, and that we can convert the one into the other as frequently as we choose.

One of the most remarkable examples of metamorphosis in the properties of a compound inorganic body has been discovered by Walter Crum, at Glasgow. He found that by continuous ebullition of acetate of alumina the salt was completely decomposed, and the acetic acid volatilised.

Alumina in its ordinary state is insoluble in water, very soluble in acids and alkalis, and absorbs colouring matters from solutions. But the modification of alumina discovered by W. Crum is soluble in water, is entirely precipitated from a watery solution by dilute acids and alkalis, and does not form lakes with decoctions of dye-woods, but is thrown down by them in a gelatinous, translucent form. Further, by concentrated acids and alkalis, the soluble alumina is again transformed into the insoluble.—*Appendix to Liebig's Letters*.

Faraday has this important conclusion:

The strange condition of Allotropism awakens within us an extraordinary train of speculation. There was a time, and that not long ago, when it was held amongst the fundamental doctrines of chemistry that the same body always manifested the same chemical qualities, excepting only such variations as might be due to the three conditions of solid, liquid, and gas. This was held to be a canon of chemical philosophy as distinguished from Alchemy; and a belief in the possibility of transmutation was held to be impossible, because at variance with this fundamental tenet. But we are now conversant with many examples of the contrary; and strange to say, no less than four of the non-metallic elements, namely, oxygen, sulphur, phosphorus, and carbon, are subject to this modification. Now if the condition of Allotropism were alone confined to compound bodies,—that is to say, bodies made up of two or more elements,—we might easily frame a plausible hypothesis to account for it; we might assume that some variation had taken place in the arrangement of their particles. But when a simple body, such as oxygen, is concerned, this kind of hypothesis is no longer open to us; we have only one kind of particle to deal with, and the theory of altered position is no longer applicable. In short, it does not seem possible to imagine a rational hypothesis to explain the condition

of Allotropism as regards simple bodies. We can only accept it as a fact not to be doubted, and add the discovery to that long list of truths which start up in every science in opposition to our most cherished theories and long-received convictions.—*Lectures on the Non-Metallic Elements*, pp. 115-16.

LIEBIG ON THE CONNECTION OF ALCHEMY AND CHEMISTRY.

In our day (observes the great chemist of Giessen) men are only too much disposed to regard the views of the disciples and followers of the Arabian School, and of the late Alchemists, respecting transmutation of metals as a mere hallucination of the human mind, and, strangely enough, to lament it. But the idea of the variable and changeable corresponds with universal experience, and always precedes that of the unchangeable. Before the introduction of the balance, and the development of chemical analysis, there were no scientific grounds for the opinion that iron existed, as such, in a red stone, or copper in a blue or green stone, and were not produced by the processes followed for their extraction. If the metals were products, *i. e.* formed by the processes, and were not educts, *i. e.* already existing, and only separated by the process,—then were the metals capable of transmutation. Every thing depended on the process employed. The notion of bodies chemically simple was first established in the science by the introduction of the Daltonian doctrine, which admits the existence of solid particles not further divisible, or atoms. But the ideas connected with this view are so little in accordance with our experience of nature, that no chemist of the present day holds the metals, absolutely, for so many simple, undecomposable bodies, for true elements. Only a few years since Berzelius was firmly convinced of the compound nature of nitrogen, chlorine, bromine, and iodine; and we allow our so-called simple substances to pass for such, not because that we know they are in reality undecomposable, but because they are as yet undecomposed; that is, because we cannot yet demonstrate their decomposability so as to satisfy the requirements of science. But we all hold it possible that this may be done to-morrow. In the year 1807, the alkalis, alkaline earths, and earths proper, were regarded as simple bodies, till Davy demonstrated that they were compounds of metals with oxygen.

It is the prevailing ignorance of chemistry, and especially of its history, which is the source of the very ludicrous and excessive estimation of ourselves with which many look back on the age of alchemy; as if it were possible, or even conceivable, that for more than a thousand years the most learned and acute men, such as Francis Bacon, Spinoza, and Leibnitz, could have regarded as true and well founded an opinion void of all foundation. On the contrary, must we not suppose, as a

matter beyond a doubt, that the idea of the transmutability of metals stood in the most perfect harmony with all the observations and all the knowledge of that age, and in contradiction to none of these ?

In the first stage of the development of science, the Alchemists could not possibly have any other notions of the nature of metals than those which they actually held. No others were admissible, or even possible ; and their views are consequently, by natural law, inevitable. We hear it said that the idea of the Philosopher's Stone was an error ; but all our views have been developed from errors, and that which to-day we regard as truth in chemistry may perhaps before to-morrow be recognised as a fallacy.

Almost every word in a Manual of Chemistry expresses an observation or a phenomenon. These observations did not present themselves to the observer ; they were laboriously sought for and obtained. What would be the present position of science without sulphuric acid, which was discovered by the Alchemist more than a thousand years ago ; without muriatic acid, nitric acid, ammonia, the fixed alkalies, the numberless compounds of metals, alcohol, ether, phosphorus, or Prussian blue ? It is impossible to form a just conception of the difficulties which the Alchemists had to overcome in their researches ; for they were of necessity the inventors of the apparatus or instruments, and of the processes, which served for the production of their preparations ; and they were compelled to make with their own hands every thing which they employed in their experiments.

Alchemy, Liebig maintains, was never at any time any thing different from Chemistry. It is utterly unjust to confound it with the gold-making of the 16th and 17th centuries. Among the Alchemists there was always to be found a nucleus of genuine philosophers, who often deceived themselves in their theoretical views ; whereas the gold-makers, properly so-called, knowingly deceived both themselves and others. Alchemy was a science, and included all those processes in which chemistry was technically applied. The achievements of such alchemists as Glauber, Böttger, and Kunckel in this direction may be boldly compared to the greatest discoveries of our century.*

The dreams of the Alchemists (says Sir John Herschel) led them in the path of experiment, and drew attention to the wonders of Chemistry, while they brought their advocates (it must be admitted) to merited contempt and ruin. But in this case it was moral dereliction which gave to ridicule a weight

* Selected and abridged from Liebig's *Familiar Letters on Chemistry*, Fourth Edit., 1859.

and power not necessarily or naturally belonging to it. But among the Alchemists were men of superior minds, who reasoned while they worked, and who, not content to grope always in the dark, and blunder on their subject, sought carefully in the observed nature of their agents for guides in their pursuit. To these we owe the creation of experimental philosophy.

EARLY EGYPTIAN CHEMISTRY.

In 1852, Mr. W. Herapath, of Old Park, whilst unrolling a mummy at the Bristol Institution, found on three of the bandages hieroglyphical characters of a dark colour, as well defined as if written with a modern pen. Where the marking-fluid had flowed more copiously than the characters required, the texture of the cloth had become decomposed, and small holes had resulted. Mr. Herapath had no doubt that the bandages were genuine, and had not been disturbed or unfolded. The colour of the marks was so similar to that of the present "marking ink," that Mr. Herapath was induced to try if they were produced by silver. With the blowpipe he immediately obtained a button of that metal; the fibre of the linen he proved by the microscope and by chemical reagents to be linen. It is therefore, he adds, certain that the ancient Egyptians were acquainted with the means of dissolving silver, and of applying it as a *permanent ink*; but what was their solvent? I knew of none that would act upon the metal, and decompose flax-fibre but nitric acid, which, we are told, was unknown until discovered by the Alchemists in the 13th century, which was about 2200 years after the date of this mummy, according as its superscription was read. A very probable speculation might be raised upon this to account for the solution of the Golden Calf by Moses, who had all his mundane knowledge from the Egyptian priests. It has been supposed that he was acquainted with and used the sulphuret of potassium for that purpose: how the inference arose, I know not. But if the Egyptians obtained nitric acid, it could only have been by the means of sulphuric acid, through the agency of which, and by the same kind of process, they could have separated hydrochloric acid from common salt. It is therefore more probable that the priests had taught Moses the use of the mixed nitric and hydrochloric acids, with which he could dissolve the statue, rather than with a sulphuret, which we have no evidence of their being acquainted with.

The yellow colour of the fine linen cloths, which had not been stained by the embalming materials (says Mr. Herapath), I found to be the natural colouring matter of the flax. The Egyptians therefore, if we judge from this specimen, did not practise bleach-

ing. There were in some of the bandages, near the selvage, some twenty or thirty blue threads: these were dyed by indigo; but the tint was not so deep nor so equal as the work of the modern dyers; the colour had been given it in the skein. One of the outer bandages was of a reddish colour, which dye I found to be vegetable, but could not individualise it. My son, Mr. Thornton Herapath, analysed it for tin and alumina; but could not find any. The face and internal surfaces of the orbits had been painted white, which pigment I ascertained to be finely powdered chalk.

To the above views Mr. Denham Smith has objected, inasmuch, he says, as there is no evidence to prove the Egyptians were ever acquainted with the art of distillation.

Mr. Thornton Herapath next examined with a microscope the stained fibres of the bandage; and on making comparative experiments with a piece of the linen wrapper, recently "marked" in the usual way with a solution of nitrate of silver, the fibre presented a very similar appearance to that of the ancient stained cloth. Hence it is concluded that the Egyptians were really acquainted with nitric acid, and employed the nitrate of silver as a marking-fluid. In this view Dr. W. Camps has also coincided, in a paper read to the Syro-Egyptian Society. "If," adds the Doctor, "this were admitted, we must then allow the Egyptians to have had a more intimate acquaintance with chemistry and chemical preparations than is generally assigned even to these very clever, intelligent, and ancient people."

The Egyptian looms were famed for their fine cotton and woollen fabrics; and many of these were worked with patterns in brilliant colours, which on dresses worn by women were very varied. They were mostly worked with the needle; but some were woven in the piece. Of these last were the linen and cotton fabrics with blue borders, the threads having been previously dyed with indigo; and stripes, or some other simple devices, were generally put into the stuff on the loom. Some of the stripes were of gold thread, alternating with red lines as a border. It was also usual to embroider patterns in the staircase style common in our worsted-work; and some were made out with long stitches that laid down the figures or devices on the surface. Some of these are in the Louvre. They are mostly cotton; and although their date is uncertain, they suffice to prove that the manufacture was Egyptian; and the many dresses painted on the monuments of the eighteenth dynasty show that the most varied patterns were used by the Egyptians more than 3000 years ago, as they were at a later period by the Babylonians, who became noted for their needlework.

The Egyptians had also the secret of dyeing cloths of various colours by means of mordants—a fact satisfactorily proved by the very manner in which Pliny describes a process which he evidently did not understand.—Sir Gardner Wilkinson, *The Egyptians in the time of the Pharaohs*.

Modern Chemistry.

THE GREAT AGENTS OF CHANGE.

THESE are gravitation, cohesion, motion, chemical force, heat, and electricity, which must, from that hypothetical time when the earth floated a cloud of nebulous vapour in a state of gradual condensation, up to the present moment, have been exercising their power and regulating the mutations of matter.—*Hunt's Poetry of Science.*

The quantity of work produced by chemical force is in general very great. A pound of the purest coal gives, when burnt, sufficient heat to raise the temperature of 8086 pounds of water one degree of the centigrade thermometer. From this we can calculate that the magnitude of the chemical force of attraction between the particles of a pound of coal and the quantity of oxygen that corresponds to it, is capable of lifting a weight of one hundred pounds to a height of twenty miles. Unfortunately, in our steam-engines we have hitherto been able to gain only the smallest portion of this work, the greater part being lost in the shape of heat. The best expansive engines give back as mechanical work only eighteen per cent of the heat generated by the fuel.—*Professor Helmholtz.*

IMPERFECTION OF CHEMISTRY.

The phenomena of chemistry are still more complicated than those of the science of the stars. Indeed, chemistry is still so far from perfection that the chemist cannot construct a particle of sugar or any other organic substance, although he knows the exact quantities of charcoal and water of which it is composed.

WHAT IS APPLIED CHEMISTRY?

A knowledge of the composition of bodies, which enables chemists to solve questions which a few years ago were supposed to be beyond their powers. The discovery of the composition of soils and of the ashes of plants enables them to see the reason why one and the same plant, grown without manure in the same soil for three, another for seven, ten, or more years, at length cease to flourish on it; why one field produces wheat, but not beans; barley, but not tobacco; and why from

another a rich crop of turnips, but no clover is obtained. Chemistry explains the operation of manures, and teaches the mode of restoring fertility to an exhausted soil. This is Applied Chemistry.

Hitherto scarcely any demand has been made upon the science of chemistry by arts, manufactures, or physiology which has not been responded to. Every question clearly and definitely put has been satisfactorily answered. Only when the inquirer had no precise idea of the problem to be solved has he remained unsatisfied.

Chemistry is the foundation of agriculture, and we cannot hope to give a scientific form and basis to this important art without a knowledge of the constituents of the soils and of the substances which constitute the food of plants. Yet the chemist was not able until lately to decompose water, and he still labours in vain to build up, out of water, carbon, and atmospheric air, most of the precious compounds which the as yet mysterious actions of vegetable and animal life present to us. He cannot yet chemically make opium, or wheat-flour, or sugar; but progress is being made in that direction, for he not only knows that the foul, horribly offensive water which has served to wash or purify coal-gas at the gas-works contains the elements of lavender, camphor, attar of roses, and other perfumes, but he can now extract a near approximation to some of them; and, strange to say, he can now produce by his art the exquisite flavour of the strawberry and pine-apple, in any climate or scene, without aid from garden-beds or sunshine.

THE GREAT DISCOVERIES IN CHEMISTRY.

Dr. Neil has thus grouped these invaluable aids to civilisation.

A century ago no person on earth knew that there existed in nature the substance which, since Dr. Priestley's discovery of it in 1774, has been named *Oxygen* (so named because of its early perceived relation to acids), although now students soon learn that it forms a large proportion, by weight, of a majority of the things—whether solid, liquid, or aëriform, living or dead—which men have yet encountered on this globe.

Nor did any one then know that Water is a compound of eight parts by weight of this oxygen and one part by weight of another element, called *Hydrogen* (so called because of its relation to water); both of which elements, when in their separate or insulated state, and at the temperature of the earth, exist in the form of air or gas, and might therefore serve as stuffing for air-cushions. Hydrogen is now popularly known as the chief material burned in our street-lamps, and as what, being very light, is used for filling balloons.

Nor was it known that all vegetable bodies—whether wood, leaves, or flowers, or fruit or seed—consist chiefly of these two elements of water combined in different proportions with another elementary substance, which has got the name of *Carbon* (so called because it was first known as being the chief part of coal).

Nor was the truth suspected that animal flesh, and soft animal substances generally, consist chiefly of the three component parts of vegetables just named, with the addition of a fourth, called *Nitrogen* (so called because first obtained from nitre); which last, when existing separately, also appears as an air or gas, and which, when mixed with one-fourth part by weight of oxygen, forms our common atmospheric air.

Nor were people aware that the whole of the countless variety of the material substances, including minerals, yet known to man are compounds of a very few simple elements; of these the four above spoken of are a very important portion, joined, atoms to atoms, in different proportions and ways, somewhat as all the words in all the languages used on earth are composed of a few simple sounds recalled by the letters of a general alphabet; which atomic elements, while in themselves absolutely unchangeable and indestructible, assume in combination or alone the three forms of solid, liquid, or gas, according to the quantity of heat pervading them.

Nor, lastly, was it known that the heat and light accompanying rapid combustion are effects of the intensity of action with which two or more combining substances are at the moment uniting into chemical compounds, one of the burning substances generally being oxygen; the same substance, however, being also capable, under other circumstances, of combining slowly and quietly, with scarcely sensible increase of temperature, and no light, as when the oxygen of the air is combining with exposed iron and converting it gradually into rust.

IMPROBABILITY OF FAMINES.

Those frightful famines by which Europe used to be ravaged several times in every century have ceased (in the 11th, 12th, and 13th centuries, the average was, in England, one famine every fourteen years); and so successfully have we grappled with famines, that there is not the slightest fear of their ever returning with any thing like their former severity. Indeed, our resources are now so great, that we could, at worst, only suffer from a slight and temporary scarcity; since, in the present state of knowledge, the evil would be met at the outset by remedies which chemical science could easily suggest. Sir John Herschel and Cuvier consider famine, in the present state of chemistry, “next to impossible.”

NOTHING LOST IN THE WORLD.

Throughout the changes which are constantly taking place in the substance of our globe, and in the living inhabitants of its surface, *one thing remains unchanged*—the absolute quantity of each of the elementary forms of matter; for whatever may be the new chemical combinations into which they enter, whatever the new physical arrangements to which they are subjected, their aggregate is the same now as it was at first. The researches of modern chemistry have most clearly established that the annihilation of matter is as impossible to man as its creation; and that in every instance in which such a destruction seems to be effected, there is in fact nothing but a change of form. Thus, in every act of ordinary combustion, the disappearance of the combustible is simply due to the formation of new compounds between its elements and the oxygen of the air, and to the diffusion of these compounds through the atmosphere; the decay of organised bodies being merely a slower kind of combustion, whose products are essentially the same in kind, and are disposed of in like manner. When we inquire into the nature and origin of either class of substances, we find that this dissemination of their materials through the atmosphere merely restores to it what was originally taken from it by the agency of living beings; thus completing a cycle of most marvellous nature.—*National Review*, No. 8.

WHAT IS AN ELEMENT ?

Mr. Faraday, in his admirable Lectures on the Non-metallic Elements, says: "Let me remark that the word 'Element' is only to be accepted in a provisional sense. Chemists are not without a hope—a hope that we trust is not irrational—of being enabled to effect changes on some of these so-called elementary forms. The phenomena of allotropism seem to afford rational ground for this hope; and thus we are unconsciously brought back into tracks of thought and action having some similitude to the doctrines of alchemy;—similar, though not identical; not the transmutation of base metals into gold, but transmutation nevertheless of a certain kind.

In pursuing this field of speculation, there is reason to believe we should derive much information as to the intimate nature of these non-metallic elements, if we could succeed in obtaining hydrogen and nitrogen in the liquid or solid form. Many gases have been liquefied: one, carbonic-acid gas, has been solidified; but hydrogen and nitrogen have resisted all our efforts of this kind. Hydrogen, in many of its relations, acts as though it were a metal; could it be obtained in a liquid or solid condition, the doubt might be settled. This great pro-

blem, however, has yet to be solved ; nor should we look with hopelessness on this solution, when we reflect with wonder, and, as I do, almost with fear and trembling, on the powers of investigating the hidden qualities of these elements—of questioning them, making them disclose their secrets and tell their tales—given by the Almighty to man !”

Dr. George Wilson has thus stated the case : “ Our globe, including the atmosphere, and the ocean with its tributary waters, consists, in very unequal proportions, of some sixty-three substances, which, according to our present knowledge, are simple or elementary. Of these chemical elements, less than a third are found distributed throughout the entire Vegetable and Animal Kingdoms. Of this fractional third, one-half occur only in small quantity, so that the *greater* part of the bulk and weight of plants and animals is made up of one-fifth or one-sixth of the whole elements ; and the *greatest* part consists but of three, carbon, hydrogen, and oxygen.”

“ THE ONE ELEMENT.”

Curious relations (says Mr. Hunt), which can be traced through certain bodies, lead us to believe that they may be only modified conditions of one element. Flint and charcoal do not at first appear allied ; but carbon, in some of its states, approaches very near to the condition of silicon, the metallic base of flint. When we remember the differences which are evident in three forms of one body—coke, graphite, and diamond,—the dissimilitude between flint, a quartz crystal, and carbon will cease to be a strong objection to the speculation.
—*Poetry of Science.*

In 1842, Mr. Grove said, in a lecture at the Royal Institution : “ Light, heat, electricity, and magnetism, motion and chemical affinity, are all convertible material affections : assuming any one as a cause, one of the others will be the effect. Thus heat may be said to produce electricity, electricity to produce heat ; magnetism to produce electricity, electricity magnetism ; and so of the rest. Cause and effect, therefore, in their relation to such forces, are words solely of convenience ; we are totally unacquainted with the generating power of each and all of them, and probably shall ever remain so. We can only ascertain the normal of their action ; we must humbly refer their causation to one Omnipresent influence, and content ourselves with studying their effects, and developing by experiment their mutual relations.”

“ I have long held an opinion,” said Mr. Faraday in 1845, “ almost amounting to conviction, in common, I believe, with many other lovers of natural knowledge, that the various forms under which the forces of matter are made manifest have a

common origin, or, in other words, are so directly related and mutually dependent, that they are convertible one into another."

MATERIALS OF THE GLOBE.

The metallic elements constitute a large majority of the whole, only thirteen of the sixty-three being non-metallic; and from within the limits of this narrow range of only sixty-three has Omnipotence selected the materials which compose our globe, and the living beings which inhabit it; out of these all the diversified forms and beings of the world are made. From the dense masses of rocks and mountains amongst inanimate things, to the fleeting atmosphere which surrounds us; from the simpler forms of animal or vegetable life to the most highly organised, however different one from another in aspect or in functions, —they have all been created out of these elements in the sixty-three. Nor is this all. By a wonderful power of adaptation, which bespeaks Omnipotence, our earth and its inhabitants are not made up of these sixty-three bodies equally distributed, but by far the greatest portion of terrestrial matter is composed of the thirteen non-metallic elements; and, yet more strange, nearly two-thirds of the whole material terrestrial universe, organic and inorganic, are composed of one alone of these simple non-metallic elements—OXYGEN. How great, then, must be the power of adaptation imposed on these elements, by which they are made to discharge so many functions, and to appear under so many different forms!—*Faraday*.

An acute writer in the *National Review*, No. 8, has thus illustrated this view: "When the term of the existence of vegetation, either wholly or in part, has been completed, if air be partially secluded, the process of decay is less complete; various new compounds are formed, which are rich in carbon and hydrogen, but poor in oxygen, and are therefore eminently combustible: yet these have a character of permanence which indisposes them to spontaneous change; and the products of the partial decay of a past vegetation may remain stored up in the depths of the earth for an unlimited period, until the ingenuity of man turns them to his own account. There are comparatively few to whom it occurs, when they are warming themselves over the winter-fire, or watching the fuel thrown into some vast steam-engine, that the combustion that cheers them by its genial glow, or generates a power of a thousand horses, is giving back to the atmosphere, in the form of carbonic acid and water, the identical carbon and hydrogen which were drawn from it by the luxuriant vegetation of the primeval world. Yet nothing is more certain than that all coal was once air, and that it was the flora of the carboniferous period which solidified it."

HARMONY OF CREATION.

The world with its ponderable constituents, dead and living, is made up of natural elements, endowed with nicely-balanced affections, attractions, or forces. Elements the most diverse, of tendencies the most opposed, of powers the most varied,—some so inert, that, to a casual observer, they would seem to count for nothing in the grand resultant of forces ; some, on the other hand, endowed with qualities so violent, that they would seem to threaten the stability of creation ; yet when scrutinised more narrowly, and examined with relation to the parts they are destined to fulfil, all are found to be accordant with one great scheme of harmonious adaptation. The powers of not one element could be modified without destroying at once the balance of harmonies, and involving in one ruin the economy of the world !

Look, for example, at the shells of sea mollusca : nearly one-half of their weight is carbonic acid. Gradually it has been collected from the surrounding medium, has pervaded the systems of these delicate creatures, has circulated in their fluids, has combined with lime, and finally been deposited by their mantles in the form of a shell. Had carbonic acid been corrosive, this could not have been. Carbonic acid would have, in that case, become totally unadapted to the performance of its destined end.—*Faraday.*

COMPENSATING FORCES IN CREATION.

Dr. Maury thus strikingly illustrates the admirable system of compensation, and the beauty and nicety with which things and principles are meted out in directions apparently the most opposite, but in proportions are exactly balanced. Thus, by the action of opposite and compensating forces, the earth is kept in its orbit, and the stars are held in suspension in the azure vault of heaven ; and these forces are so exquisitely adjusted, that, at the end of a thousand years, the earth, the sun, and moon, and every star in the firmament, is found to come and stand in its proper place at the proper moment.

When the little snowdrop was created, the whole mass of the earth, from pole to pole, and circumference to centre, must have been taken into account and weighed, in order that the proper degree of strength might be given to its tiny fibres.

NUMBERS IN NATURE.

Physical Science shows that numbers have a significance in every department of nature.

Two appears as the typical number in the lowest class of plants, and regulates the pairing or marriage of plants and animals.

Three is the characteristic number of that class of plants which has parallel veined leaves, and is the number of joints in the typical digit.

Four is the significant number of those beautiful crystals which show that minerals as well as stars have their geometry.

Five is the model number of the highest class of plants, with reticulated veins and branches; is the typical number of the fingers and toes of vertebrate animals, and is of frequent occurrence among star-fish.

Six is the proportion number of carbon in chemistry, and 3×2 is a common number in the floral organs of monocotyledonous plants, such as lilies.

Seven appears as significant only in a single order of plants (*Heptandria*); but has an importance in the animal kingdom, where it is the number of vertebræ in the neck of mammalia; and, according to Edwards, the typical number of rings in the head, in the thorax, and in the abdomen of crustacea.

Eight is the definite number in chemical composition for oxygen, the most universal element in nature, and is very common in the organs of sea-jellies.

Nine seems to be rare in the organic kingdom.

Ten, or 5×2 is found in star-fishes, and is the number of digits in the fore and hind limbs of animals.

Without going over any more individual numbers, we find multiple numbers acting an important part in chemical compositions and in the organs of flowers; for the elements unite in multiple relations, and the stamens are often the multiples of the petals. In the arrangement of the appendages of the plant we have a strange series, 1, 2, 3, 5, 8, 13, 21, 34, which was supposed to possess virtues of an old date, and before it was discovered in the plant. In natural philosophy, the highest law, that of forces acting from a centre, proceeds according to the square of numbers. In the curves and relative length of branches of plants there are evidently quantitative relations which mathematics has not been able to seize and express.

UNITY OF THE DEITY.

In examining the human structure, and comparing it with that of animals in general, a new and grand evidence has been afforded of the unity of the Divine action; supplying the last argument required, and left untouched by the famous Cudworth, to refute the old atheistic doctrine of Democritus and his followers, who, it will be remembered, resolved the existence of men and animals into the fortuitous concourse of atoms—by demonstrating the existence, in the Divine mind, of pattern, or plan, prior to its manifestation in the creation of man. “The evidence of unity of plan in the structure of animals

testifies to the oneness of their Creator, as the modifications of the plan for different modes of life illustrate the beneficence of the designer.”*

Man is no longer regarded as though he were distinct in his anatomy from all the rest of the animal creation ; but his structure is perceived to be an exquisite modification of many other structures, the whole of which have been now recognised as modifications of one and the same general pattern. Every one of the 260 bones which may be enumerated in the human skeleton can be unerringly traced in the skeletons of many hundred inferior animals ; and the human anatomist of our day begins to comprehend the nature of his own structure in a way never dreamed of by his predecessors.—*S. Warren's Lecture on Intellectual and Moral Development of the present Age.*

Nearly sixty years since Paley wrote : “Of the unity of the Deity, the proof is the uniformity of plan observable in the system,” bespeaking “the same creation and the same Creator ;” almost prophetic words, which have been so strikingly illustrated by the superior science of the present day.

WHAT IS ATMOSPHERIC AIR ?

The term Atmospheric Air conveys to the mind of the chemist the idea of a number of properties. No mortal eye has ever seen a particle of air ; for sight presupposes a certain effect produced on the eye, which particles of air are quite incapable of producing. They possess, however, other properties, which chemistry brings to view, and by which the chemist not only ascertains their presence when they escape the notice of others, but he is also enabled by them to show that this invisible, impalpable material consists of several other equally invisible substances. By his exact knowledge of the properties, he can separate them from each other, weigh them, and make their presence manifest to others. He is able to show that the air which burns in our street-lamps consists of five or six totally different airs. He points out, in a constituent of atmospheric air, employed in respiration, one of the most indispensable requisites for animal life ; and in a product of respiration, one equally important to vegetable life. He exhibits the intimate connection between the visible and invisible material world, of the existence of which our ancestors had no idea. He is enabled to do all this by his knowledge of the peculiar properties of these bodies, acquired by the means of visible phenomena, or such as can be recognised by the senses. He must first bring these substances in contact with others to render these phenomena manifest ; but when he has done this, they then become more distinct

* See the *Archetype and Homologies of the Vertebrate Skeleton*, &c., by Richard Owen, F.R.S.

than the tones of a chord when struck, and as intelligible as the black lines and characters which convey to a far distant friend our invisible thoughts.—*Liebig's Familiar Letters*.

CHEMICAL COMPOSITION OF THE ATMOSPHERE.

When we reflect upon the number of gases and vapours that are disengaged on the surface of the globe from all the decompositions of the great animal and vegetable kingdoms, together with all the poisonous matter of infectious disease, we might expect, at least, to find a long list of elements in the analysis of the atmosphere. But not so. Oxygen, nitrogen, vapour of water, and a small fraction of carbonic-acid gas, are all at present detected. This is the same in town or country, on the plain or the mountain-top; or perhaps it would be more correct to say, chemistry is not yet sufficiently advanced to detect the difference. Surely the air that sweeps the Pontine marshes, branding the native of that treacherous climate with the appearance of age in his youth, or that air which surrounds the pallid sedentary mechanic in the densely populated city, cannot be the same which gives the sailor and the rustic farmer such a ruddy countenance. Therefore, at present, the best test of the purity of an atmosphere is its effect on the constitution. In 100 parts of atmospheric air there are twenty-three parts of oxygen gas, and seventy-seven of nitrogen (Dumas and Boussingault). The quantity of carbonic-acid gas is variable: from the mean of various experiments it exists in the proportion of one volume in 2000 of atmospheric air. This proportion is greater near the level of the sea in summer than in winter, and greater during the night than during the day, and rather more abundant on the summit of mountains than on the plains.—*Journal of Public Health*.

DAVY'S EARLY DREAM.

Humphry Davy, when nineteen summers old, among other things, concluded that oxygen, as it exists in the atmosphere, is a compound of real oxygen and a matter of light; that when a taper burns, this light is set free, while the wax unites with the actual oxygenous principle of oxygen, and melts "into thin air." That when a man inspires, this "phos-oxygen" (such was the name he put upon the ordinary oxygen of the atmosphere) is absorbed by the blood, carried to the brain, and there decomposed into true oxygen and light; and that the light thus liberated within the most intimate recesses of "the golden bowl," from which the stream of higher life appeared to permeate the body, is the nervous energy, and the proximate cause of sensation, perception, and emotion. In sad and sober truth, the enthusiast was then a materialist; and this dazzling

vision, which sanctified the divinity of nature to his kindled imagination, was a compromise between his impersonal piety and the eminently practical but brilliant science by which he was taken captive.—*North British Review*, No. 3.

MATERIALITY OF HEAT.

How much the progress of science depends on the mode in which phenomena are interpreted by the first observers, is strikingly illustrated in the case of certain experiments of Robert Boyle. He observed that when copper, lead, iron, and tin were heated to redness in the air, a portion of calx was formed, and there was a constant and decided increase of weight. (*Experiments to make Fire and Flame ponderable*, 1673.) This experiment he repeated with lead and tin in glass vessels hermetically sealed, and found still an increase of weight; but observed further that when the "sealed neck of the retort was broken off, the external air rushed in with a noise." (*Additional Experiments*, No. v.; and *a Discovery of the Perviousness of Glass to ponderable parts of Flame*, exp. iii.) From this he reasoned correctly, that in calcination the metal lost nothing by drying up, as was generally supposed, or that if it did, "by this operation it gained more weight than it lost." (*Coroll.* ii.) But this increase of weight he attributed to the fixation of heat, stating it as "plain that igneous particles were trajected through the glass," and that "enough of them to be manifestly ponderable did permanently adhere." Had he weighed the sealed retort before he broke it open, he must have concluded that the metal had increased in weight at the expense of the enclosed air. He stood, in fact, at the very brink of the Pneumatic Chemistry of Priestley; he had in his hand the key to the great discovery of Lavoisier. How nearly were these philosophers anticipated by a whole century, and the long interregnum of phlogiston prevented! On what small oversights do great events in the history of science, as of nations, depend! —*Prof. Johnstone, Proc. British Assoc.* vol. vii.

CHEMICAL AGENCIES OF LIGHT.

In by far the larger number of cases in which light is evolved, its manifestations can be directly traced to chemical combinations; whilst, conversely, light is often a most powerful agent in bringing about chemical change. In fact, it may be doubted whether light does not alter the structure or composition of all matter through which it passes, or on which it falls. Upon such an alteration depend not only all the phenomena of photography, and numerous chemical changes of a most important character, but also the sustentation of all organic life and our own sensibility to visual phenomena. For

it is by the extraordinary influence of light upon the surface of the growing plant, that it is able to separate the inorganic elements of water, carbonic acid, and ammonia, and to unite them into those new and peculiar compounds—starch, oil, albumen, and their derivatives, which serve not only for the extension of the vegetable fabric, but also for the nutrition of the animal body; so that without light, as Lavoisier truly said, nature were without life and without soul. That the influence of light is exerted in providing the material for vegetable growth by quasi-chemical action, is capable of proof by the direct experiment, that, *ceteris paribus*, the quantity of carbonic acid decomposed by a plant in a given time is proportioned to the amount of light that has fallen upon it.—*National Review*, No. 8.

EFFECT OF COLOURED LIGHT ON GERMINATION.

Mr. Lawson of Edinburgh has been accustomed to ascertain the commercial value of seeds by experimental germination, and so to determine their value in the market. The process ordinarily occupies from twelve to fifteen days; but Mr. Lawson found that by using *blue glass* he was enabled to determine the value of the seeds in two or three days, which is to him a saving of 500%. a year.

Mr. J. H. Gladstone gives us the results of hyacinths grown under very varied influences of light, and solar heat, and chemical agency: that the yellow ray diminishes the growth of rootlets and the absorption of water; the red ray hinders the proper development of the plant; and total darkness causes a rapid and abundant growth of their rootlets, and prevents the formation of the green colouring-matter, but not that of the blue flower, nor of the other constituents of a healthy plant.

It has been observed that blue rays retard germination at first, although they probably accelerate the growth of the plant afterwards; the act of germination being attended with absorption of oxygen, but the process of development being, on the contrary, attended with the extrication of this gas.

COLORIFIC EFFECT OF THE SUN'S RAYS.

The power of the solar rays in developing fine colours is perhaps best seen on the sides of apples, peaches, &c., which, exposed to the midsummer sun, become highly coloured.

During the winter of 1851, a wall-flower afforded Mr. Adie of Liverpool a proof of the like effect: in the dark months there was a slow succession of one or two flowers of uniform pale-yellow hue; in March streaks of a darker yellow colour appeared on the flowers, and continued slowly to increase, till

in April they were variegated brown and yellow of rich strong colours.

THE COLOURING OF FLOWERS.

M. Fritsch, the German botanist, has shown that the colouring of flowers is intimately connected with the alternations of the seasons. In Germany, he finds that invariably the number of flowers increases from December to July. White flowers are the most numerous during the whole of the year when plants are in blossom; then come yellow, orange, blue, violet, green, and lastly, the indigo flowers, which are the most uncommon.

The law of the increase of flowering is closely connected with the mean temperature; but from time to time anomalies are exhibited which change of temperature alone can explain: such is the rapid decrease of the number of flowering plants from the end of July to that of August. From January, when all the flowers are white, to the vernal equinox, the relative number of white flowers rapidly decreases; after which the proportion increases till the middle of May, and then insensibly diminishes till the season of frosts. Setting aside the very few yellow flowers which appear in February and March, the proportion of flowers of that colour increases from the beginning of April to the end of June; then it remains stationary till the middle of August, after which it increases again till the frosts. The proportional number of red flowers gradually diminishes from February to the end of April; increasing till the end of August, after which it decreases till October; it then rises again till November, when most of the cultivated flowers are of that colour. The green or greenish flowers diminish in number from March till the end of May, after which the proportion is about uniformly maintained till winter. Blue flowers increase till the middle of April; then decrease till the summer solstice, and next ascend to the number reached in April, after which they rapidly decrease, and totally cease on the arrival of frosts.

A table of these observations shows that each colour rises twice, and decreases twice. Whenever the white flowers increase, the yellow decrease, and *vice versâ*. The red and green always correspond, as do the blue and violet flowers. In conclusion, these laws apply to species, not to individuals.

THEORY OF RESPIRATION.

A man's chest contains nearly 200 cubic inches of air; but in ordinary breathing he takes in at one time and sends out again only about 20 cubic inches, the bulk of a full-sized orange; and he makes about 15 inspirations in a minute. He vitifies, therefore, in a minute about the sixth part of a cubic

foot ; but which, mixing, as it escapes, with many times as much of the air around, renders unfit for respiration three or four cubic feet. The removal of this impure air, and the supply in its stead of fresh air, is accomplished thus : the air which issues from the chest, being heated to near the temperature of the living body, viz. 98 degrees, and being thereby dilated, is lighter, bulk for bulk, than the surrounding air at the ordinary temperature ; it therefore rises in the atmosphere, to be diffused there, as oil set free under water rises : in both cases a heavier fluid is, in fact, pushing up and taking the place of a lighter. This beautiful provision of nature, without trouble to the person, or even his being aware of it, is relieving him at every instant from the presence of a deadly though invisible poison, and replacing it with pure vital sustenance ; and the process continues while he sleeps as while he wakes, and is as perfect for the unconscious babe, and even the brute creature, as for the wisest philosopher. In aid of this process come the greater motions in the atmosphere, called winds, which mingle the whole, and favour agencies which maintain the general purity.—*Dr. Neil Arnott.*

IMPORTANCE OF VENTILATION.

That the importance of the constant substitution of pure air taken from the general atmosphere for the contaminated air of enclosed localities has been so lately understood even by scientific men, and is still so little understood by the mass of the people, is explained by the fact, that a hundred years ago nobody on earth knew anything of oxygen and nitrogen ; or that the air we breathe, consisting of these, is as much a material substance as the water we drink or the food we eat,—indeed, consists of similar elements, only in different combination and form,—and that it can carry poison like these. Then, although men have long been aware that arsenic, prussic acid, and the other solid and liquid poisons, may all be rendered harmless,—nay, in certain cases may even be used as medicines when copiously diluted with pure water,—many have yet to learn that aërial poisons also can be rendered quite harmless by large admixture of pure air. In a locality where a deadly contagion prevails, the atmosphere at a short distance above it is no more contaminated by it than the deep stream of the Mississippi is contaminated by a child washing a foul rag near its bank : and mechanical art can now draw down pure air from the sky, and fill with it any dwelling, as certainly and as steadily as gas for burning is supplied to all persons who want it from the central gas-holder of a town.

The reasons of this imperfect ventilation are, that air under common circumstances is invisible ; that scarcely two hundred

years have passed since scientific men began to suspect that air was at all a ponderable space-occupying substance; and only in our own day—since it has been used as stuffing for air-pillows, and one kind with the name of coal-gas has been distributed and sold by measure from pipes, as water is. Hence people generally conceived of it as being truly a thing; that only about one hundred years ago did chemists learn that air or gas is not a distinct substance of a permanent nature, but is one of the three forms called solid, liquid, and æriform, which certainly most, probably all, elementary substances may assume under different degrees of heat, compression, and combination: that the particular substance, for instance, to which the name of oxygen was given soon after its discovery, by Dr. Priestley in 1783, and which in its separate state, at the temperature of our earth, exists only as an air that might serve as a stuffing for cushions, yet constitutes eight-ninths by weight of all the water on our globe, about one-fourth of all the earth and stones, and a large proportion of the flesh and other parts of all animals and vegetables.—*Dr. Neil Arnott.*

ANALYSIS OF ATMOSPHERIC AIR.

Professor Liebig discovered, in 1850, a beautiful process for analysing atmospheric air. He found that one part of pyrogallic acid dissolved in five of water, and added to a solution of potassa, gives a liquid that will absorb oxygen air as rapidly as a pure potassa solution does carbonic acid. Availing himself of this fact, he has been enabled by a simple process to make analyses of atmospheric air equal to the best heretofore obtained by other processes.

PLANTS IN SLEEPING-ROOMS.

Plants are generally understood to be hurtful at night both in sleeping and sitting rooms, but beneficial by day, by two contrary operations, which are thus explained in *Kemp's Handbook of Gardening*:

“Plants convert oxygen and carbon, which they receive from the soil and air, into carbonic acid, which they exhale at night. This being a deadly and dangerous gas to human beings, plants and flowers are not considered healthy in a sitting or bed room during the night. In the day they give off oxygen, especially in the morning, which is reputed to render the morning air so fresh and exhilarating. They are very useful in absorbing from the air the carbon which is so injurious to animal life; and they purify stagnant water in the same way.”

Dr. Sexton, in a communication to *Notes and Queries*, 2d series, No. 29, thus illustrates this vexed question:

There are two distinct and apparently opposite processes going on

in the plant. First, the decomposition of carbonic acid, the fixation of the carbon for the purpose of building up its own tissues, and the liberation of the oxygen. This constitutes vegetable nutrition. Second, the exhaling carbonic acid, the result of the union of the oxygen of the atmosphere with the carbon of the vegetable tissues. This is analogous to respiration.

The first of these processes is not only beneficial to animal life, but absolutely essential to its existence ; for as the animal inhales oxygen and exhales carbonic acid in the process of respiration, if some agency did not work out the reverse change, the whole of the oxygen in the atmosphere would be used up in a certain length of time (800,000 years, according to Professor Dumas), and animal life consequently disappear. But, as it is, animals and plants are thus mutually dependent upon each other ; and this is the case, not merely with regard to carbonic acid, but also some other compounds, such as ammonia, water, &c., which are formed in animals and decomposed in plants. So far, then, it is healthy to have plants in rooms.

But there is the second process—a kind of decay, or by some looked upon as a true respiration ; and as this is precisely what occurs in animals, it must of course add to the carbonic acid of the atmosphere, and thus produce an effect prejudicial to animal life. If both these processes were carried on to the same extent, the one would as a matter of course counteract the other, and neither would produce either good or evil as to its effects upon the atmosphere. But as the former, under general circumstances, preponderates excessively over the latter, it is on the whole healthy to live among plants.

There are circumstances, however, in which the respiratory process is active, and the nutritive at a stand-still ; where the influence of the vegetable upon the atmosphere will be injurious to animal life. One of these circumstances is the absence of sunshine, or daylight, as these stimuli are necessary to the carrying on of the process of nutrition in the plant. It is therefore injurious, more or less, to sleep in a room in which there are plants.

Notwithstanding this minute inquiry into the matter, in the *Quarterly Review*, No. 139 (Art. "The Flower Garden"), we find the fear of exhalations from flowers at night treated as a popular error.

FIRE AND PHLOGISTON.

The fiction that Fire is a substantial, though subtle, material element of nature, had been promulgated by Empedocles more than four centuries B.C. ; handed down to the polypharmacists, it had played but a small figure in their doctrine ; brought to Europe once more, the Alchemists had written not a little about it, but had made nothing of it as a theoretic centre : but now it was destined to quicken the whole mass of a growing chemistry, and to give that unity to all its parts, of which they stood more in need than ever. In fine, the ancient Greek, if not Egyptian, matter of fire, the empyrean element of the old quaternion, was at length recognised, set apart and consecrated by the hierophants of a young European science under the classical name and style of Phlogiston.

Here is a familiar illustration of this positive chemistry.

A lighted candle burns till it is done, giving out flame or matter of fire all the while :—for what reason, but because a candle is a compound of candle-matter and phlogiston, because that compound is decomposed when it burns, and because phlogiston is thereby set free and shows itself in the flame from the beginning to the end of the process? The pure aphlogisticated candle-matter is also liberated of course, little by little, as the taper burns from top to socket; that candle-matter turning out to be carbonic-acid gas and water, as discovered by later methods of research; so that, according to the phlogistic chemistry, tallow should have been tabulated as a compound of fire with water and fixed air: counting the ashes of the wick and oil, this was neither more nor less than the experiment of the Greek physiologists, after all :—phlogiston or fire, carbonic acid or air, moisture or water, and ashes or earth! Again, a stick of brimstone burns away with a blue flame and a suffocating vapour, and the residue of its combustion is sulphurous acid; in the language of the phlogistians, brimstone is a compound of two things, sulphurous acid and phlogiston; and when it is suffered to burn, it gives out its phlogiston, or flame of fire, and there remains its dephlogisticated sulphur, or sulphurous acid, in the separated state.

What a thing fire must have been to the primitive man the first time it flashed upon him! Say that he kept watch over his people; that at the chilliest hour of the night, just before sunrise, he noticed how a dry stick grew warm when rubbed against his club; that he rubbed them again more stoutly still, and it became hot: at it again, with the wonder of a child, and the strength of twenty men, he flung it down, for it scorched his hand; yet he could not choose but try again, and it smoked; again and again, quicker and quicker, longer and longer, he pursued the wild experiment until it burst into flame.—*North British Review*, No. 35.

THE FATE OF LAVOISIER.

Antoine Laurent Lavoisier, "the French lawgiver of chemistry," was born at Paris in 1743. He was educated at the College Mazarin, and having studied mathematics, astronomy, and botany, he took lessons in chemistry from old Rouelle, and to this science he dedicated himself, determined in his choice by the recent brilliant discoveries of Dr. Black. When only twenty-one years of age, he obtained the prize offered by the government for the best essay on lighting the streets of Paris; and to enable himself to judge of the intensity of the light afforded by lamps, he kept himself six weeks in total darkness, in order to intensify the sensibility of his eye. He now renounced Parisian society for the secluded pursuit of science; and put himself upon short commons of bread and milk, when he found that the want of air and exercise did him harm. In 1768, he was admitted an associate of the French Academy; and finding that he needed a good income for his studies, he obtained the appointment of a farmer-general of the public revenues. The chemists now said he had forsaken chemistry, and the farmers looked upon him as an interloper; but he

eventually proved the best of farmers, and the greatest of the chemists of his day. He was next appointed to superintend the government saltpetre works, and in 1790 was made a member of the famous commission on weights and measures.

Meanwhile the revenue-farmer was working out a vast scheme of chemical discovery and doctrines, upon which he published forty memoirs within fifteen years. It is also recorded of him that he engaged in some of the most repulsive of chemical investigations from motives of humanity. Yet all his services and all his fine qualities could not save him from the revolutionary scaffold. Upon some paltry accusation of having authorised or winked at the putting of too much water on the Republic's tobacco, a number of the farmers-general were condemned to death; and Lavoisier was one of them. To avoid arrest, he secreted himself for some days in a cabinet of the Academy; whence he was dragged forth, like a skulking malefactor, insulted by a mock trial, and condemned to death. In answer to a request for a respite of some days, in order to finish certain experiments, which he stated were of importance to the interests of mankind, he was coldly informed by the public accuser that the Republic had *no need of chemists*, and that the course of justice could not be delayed: he was then led to the guillotine, May 8, 1794.

The truly pathetic circumstance connected with this homicide was the fact, that the discoverer was just at the middle of his work, as he supposed. These are the last two sentences he ever wrote: "This is not the place to enter into any details concerning organised bodies; indeed, I have purposely avoided that subject, and that is the reason why I have refrained from speaking of the phenomena of respiration, sanguification, and animal heat. I shall return some day soon to these subjects." He never returned in the body; but his spirit is with us still, the nobler portion of the legacy he left to his disciples.

It is impossible within our limits to trace the succession of particulars in the progress of Lavoisier's career. The crowning moment was, perhaps, the following discovery: Oxygen had been discovered by Priestley and by himself: he had ascertained that it is the oxygen of the atmospheric air that becomes fixed (or absorbed and combined with) when brimstone is burnt, or a metal calcined; so that the calx of quicksilver was known to contain at least mercury and oxygen, whatever else it might contain. He therefore took a known weight of mercurial rust, and drove the oxygen out of it by heat (for simple heating decomposes that oxide), but did so in such an apparatus as enabled him to catch and retain that oxygen, as well as to preserve the liberated quicksilver. He next recalcined this same mercury, by means of the same oxygen as had been

just expelled from the original calx employed; and he thereby obtained the same weight of the calx of mercury as had been introduced into the apparatus at the beginning of the experiment. This was an express illustration of the fact that the red rust of quicksilver is a compound of nothing ponderable but mercury and oxygen, instead of quicksilver being (as had been so long and loyally believed) a compound of its own calx with the positively light phlogiston. When it was made out that the sum of the weights of the mercury and the oxygen, obtainable by heat from any known weight of mercurial calx, is exactly equal to that weight, the experimental demonstration was complete. Yet it is a strange mistake to suppose that the history of true Chemistry reaches no further back than the period of this great reform. Ages were required to collect the world of phenomena of which Chemistry consisted before Lavoisier appeared. It required innumerable observations before men were able to attempt the explanation of that most striking though familiar phenomenon, the burning of a candle,—before they could seize the hidden clue which led to the conclusion that the rusting of iron in the air, the bleaching of vegetable colours, and the respiration of animals, were all dependent on the same cause as the combustion of inflammable substances.—*Abridged from the North British Review*, No. 35.

COLOURED FIRES.

Mr. F. A. Abel, Director of the Chemical Establishment of the War-Department, has found the most important materials for producing Coloured Fires to be—

The oxide and sulphide of copper, and the chlorate of copper and potassa; the nitrate of lead, the sulphide of arsenic (orpiment); the sulphide of mercury (*Elhiops mineral*), and the sub-chloride (calomel); zinc, antimony, and iron, as metals, in the state of filings, &c.; the carbonate, nitrate, and chloride of baryta; and the carbonate and nitrate of strontia. Chloride of potassa is largely employed to increase the vehemence of the combustion of many compositions containing colouring substances, whereby the brilliancy of the resulting tints is much heightened. The chlorate of baryta has lately been prepared on a very large scale for pyrotechnic compositions. In endeavouring to prepare a compound of the chlorate of copper with ammonia (similar to the so-called ammonio-nitrate of copper), as a material for a brilliant purple fire, Mr. Nicholson has obtained a beautifully crystalline compound, of so powerfully explosive a character that even its syrupy solution detonates sharply when struck with a hammer upon an anvil. The substance in question is more dangerous to manipulate with than fulminate of mercury, but it undergoes gradual decomposition on exposure to air, accompanied by a diminution of its explosive properties. This compound has led to the observation that the ammonio-nitrate of copper, when thoroughly dry, also possesses slight detonating properties.

In distilling the metal magnesium, which resembles zinc, if

the current of hydrogen is too strong, a little metallic powder is carried out of the apparatus along with the hydrogen gas. If this powder is ignited, it burns with one of the most beautiful flames it is possible to imagine: this experiment would make a charming exhibition for a lecture-room.

ALDINI'S FIRE-PROOF DRESSES.

In Savoy, Corsica, Cornwall, and Scotland, is found a fibrous mineral, which when woven produces a fire-proof cloth; whence its name *Asbestos*, unconsumable. As the ancients were acquainted with the art of weaving this cloth, it was probably employed in the performance of some of their miracles—in enabling the victims of superstition to undergo without hazard the trial of ordeal by fire, when clad in asbestos garments and gloves made to imitate the human skin.

In our own times, by similar means to the above, the art of defending the hands and face, and, indeed, the whole body, from the action of intense fire has been applied to the nobler purposes of saving human life, and rescuing property from the flames. Sir Humphry Davy had long ago shown, in his safety-lamp for lighting mines, that the flame, being surrounded with wire-gauze, was prevented setting fire to the inflammable air without by the conducting and radiating power of the wire-gauze carrying off the heat of the flame, and depriving it of its power. The Chevalier Aldini of Milan has applied this material, with other badly conducting substances, as a protection against fire. The incombustible pieces of dress which he used for the body, arms, and legs were formed of stout cloth steeped in a strong solution of alum; while those for the head, feet, and hands were made of asbestos, or mountain-flax. The head-dress was a cap enveloping the head down to the neck, having perforations for the eyes, nose, and mouth. The stockings and cap were single; but the gloves were made of double asbestos cloth, to enable a fireman to handle burning or red-hot bodies. Over these was worn a metallic dress of five pieces, made of iron-wire gauze, the interval between its threads being the twentieth part of an inch. These pieces were a cap, with a mask large enough to leave a proper space between it and the asbestos cap; a cuirass with brassets; a piece of armour for the trunk and thighs; a pair of boots of double wire-gauze; and an oval shield of wire-gauze stretched over a slender iron frame.

To prove the safety of this apparatus to the firemen, Aldini showed that a finger first enveloped in asbestos, and then in a double case of wire-gauze, might be held a long time in a flame of a spirit-lamp or candle before the heat became inconvenient.

A fireman wearing a double asbestos glove, and the palm protected by a piece of asbestos cloth, seized with impunity a large piece of red-hot iron, and carried it deliberately 150 feet, inflamed straw with it, and brought it back to the furnace. On other occasions, the firemen handled blazing wood and burning substances, and walked during five minutes upon an iron grating placed over flaming fagots. In order to show how the head, eyes, and lungs were protected, the fireman put on the asbestos and wire-gauze cap and the cuirass, and then plunged his face into a fire of shavings; and in another trial at Paris, a fireman placed his head in the middle of flaming hay and wood, and resisted the fire ten minutes. In another trial, a fireman safely carried a child in a wicker-basket covered with metallic gauze (the child only wearing a cap of amianthine cloth) through a narrow place where flames from fagots and straw raged eight yards high.

Sir David Brewster observes in his *Natural Magic*: "It is a remarkable result of these experiments, that the firemen are able to breathe without difficulty in the middle of the flames. This effect is owing not only to the heat being intercepted by the wire-gauze as it passes to the lungs, in consequence of which the temperature becomes supportable, but also to the singular power which the body possesses of resisting great heats, and of breathing air of high temperatures."*

ASBESTOS.

Nearly two centuries since, the fire-proof property of Asbestos was publicly proved in England. Dr. Plot records that, at a meeting of the Royal Society in 1676, a merchant lately come from China exhibited a handkerchief made of Salamander's wool, or *Linum Asbesti*, which, to try whether it were genuine or no, was put into a strong charcoal fire, in which, not being injured, it was taken out, oiled, and put in again. The oil being burnt off, the handkerchief was taken out again, had only lost 2 dr. 5 gr. of its weight, but was more brittle than ordinary; but when it had grown cold, it nearly recovered its tenacity and weight. The merchant stated that he had received the handkerchief from a Tartar, who told him that among the Tartars this sort of cloth was sold at 80 $\frac{1}{2}$ sterling the China ell, which is less than our ell; he added that the Chinese greatly used this cloth in burning the bodies (to preserve the ashes) of great persons; and that in Tartary Asbestos is "affirmed to be made of the root of a tree."

Sir Hans Sloane possessed in his museum a purse made of Asbestos, which he purchased of Dr. Franklin, who thus relates

* See "Protection from Intense Heat," in *Curiosities of Science*, First Series, p. 191, 192.

the circumstance in one of his letters: "Sir Hans Sloane heard of it, came to see me, and invited me to his house in Bloomsbury Square, showed me all his curiosities, and persuaded me to add that (the Asbestos purse) to the number, for which he paid me handsomely."

CHEMISTRY OF A BLAST-FURNACE.

Had the results of combustion not been volatile, the combusive action would have been continually impeded. There can scarcely be conceived a more beautiful balance of power designed for a specific end than this; yet so familiar has the result become to us, so unnoticed by its very perfection, that an effort of chemical reasoning is required to enable us justly to appreciate this point in relation to the chemistry of carbon. The enormous quantity of ponderable, yet invisible, carbon removed in the draught of our larger fireplaces is, on its first announcement, startling; yet nothing admits of more satisfactory proof. Through an average-sized iron blast-furnace there rushes hourly no less a quantity of atmospheric air than six tons; carrying off 56-100ths, or more than half a ton, of carbon in the form of carbonic acid.—*Faraday*.

A striking instance of economic talent, says a writer in the *British Quarterly Review*, came to our knowledge in the district of Alston Moor. From the smelting earths of one "house," an arched tunnel conducts the smoke to an outlet at a distance from the works, in a waste spot, where no one can complain of it. The gathering matter, or "fume," resulting from the passage of the smoke is annually submitted to a process by which at that time it yielded enough of lead to pay for the construction of a chimney. A similar tunnel-chimney, three miles in length, has been erected at Allendale. Its fumes will yield thousands of pounds sterling per annum. Truly, here it may be said that smoke does not end in smoke.

PRODUCTS OF COMBUSTION IN GAS AND OIL LAMPS.

Mr. Faraday has shown that oil and gas each contains carbon and hydrogen, and each requires the addition of oxygen to bring about combustion. The *light* is one of the indications of the intensity of this union, and the substances which result from it are mainly two—*water*, by a combination of some of the oxygen with the hydrogen, and *carbonic acid*, by the combination of more of the oxygen with the carbon. The quantity of these two substances produced, owing to the enormous absorption of oxygen during the combustion, would by many persons be deemed quite extraordinary.

A pint of oil, when burned, produces a pint and a quarter of wa

and a pound of gas, more than two pounds and a half of water ; the increase of weight being due to the absorption of oxygen from the atmosphere, one part of hydrogen taking eight parts (by weight) of oxygen to form water. A London Argand gas-lamp, in a closed shop-window, will produce in four hours two pints and a half of water. A pound of oil also produces nearly three pounds of carbonic acid ; and a pound of gas, two and a half pounds of carbonic acid. For every cubic foot of gas burned, rather more than a cubic foot of carbonic acid is produced.

As the water produced deadens the effect of the flame, and as the carbonic acid is very deleterious to the lungs, Mr. Faraday has contrived a very ingenious mode of carrying both off, without allowing them to mix with the air of the room. Air is admitted to feed the flame nearly in the usual way ; but when the products of combustion have arrived at the top of the glass chimney, their progress is arrested by a covering of talc, and they are made to pass down between the chimney and another larger glass chimney concentric with it. The open space between the two chimneys communicates with a pipe, which is conducted into the open air. The carbonic acid, aqueous vapour, smoke, and other emanations from the flame, have no means of escape except through this tube, and they are thus wholly cut off from contact with the air of the room ; while the light is brighter, the space around the lamp cooler, and the air of the room less vitiated, than when common open burners are used. This improvement was first devised for the lighting of the Athenæum Club, and has since been adopted in Buckingham Palace.

ANIMAL HEAT AND CHEMICAL PROCESSES.

To the builders of the automata of the last century, men and animals appeared as clockwork which was never wound up, and created the force which they exerted out of nothing. They did not know how to establish a connection between the nutriment consumed and the work generated. Since, however, we have learnt to discern in the steam-engine this origin of mechanical forces, we must inquire whether something similar does not hold good with regard to men. Indeed, the continuation of life is dependent on the consumption of nutritive materials : these are combustible substances, which, after digestion and being passed into the blood, actually undergo a slow combustion, and finally enter into almost the same combinations with the oxygen of the atmosphere that are produced in an open fire. As the quantity of heat generated by combustion is independent of the duration of the combustion and the steps in which it occurs, we can calculate from the mass of the consumed material how much heat, or its equivalent work, is thereby generated in an animal body. Unfortunately the diffi-

culty of the experiments is still very great ; but, within those limits of accuracy which have been as yet attainable, the experiments show that the heat generated in the animal body corresponds to the amount which would be generated by the chemical processes. The animal body, therefore, does not differ from the steam-engine as regards the manner in which it obtains heat and force,* but does differ from it in the manner in which the force gained is to be made use of. The body is, besides, more limited than the machine in the choice of its fuel : the latter could be heated with sugar, with starch, flour, and butter, just as well as with coal or wood ; the animal body must dissolve its materials artificially, and distribute them through its system. It must further perpetually renew the used-up materials of its organs ; and as it cannot itself create the matter necessary for this, the matter must come from without. Liebig was the first to point out these various uses of the consumed nutriment. As material for the perpetual renewal of the body, it seems that certain definite albuminous substances which appear in plants, and form the chief mass of the animal body, can alone be used. They form but a portion of the mass of nutriment taken daily ; the remainder, sugar, starch, fat, are really only materials for warming, and are perhaps not to be superseded by coal, simply because the latter does not permit itself to be dissolved.

If, then, the processes in the animal body are not in this respect to be distinguished from inorganic processes, the question arises, Whence comes the nutriment which constitutes the source of the body's force ? The answer is, from the vegetable kingdom ; for only the material of plants, or the flesh of plant-eating animals, can be made use of for food. The animals which live on plants occupy a mean position between carnivorous animals, in which we reckon man, and vegetables, which the former could not make use of immediately as nutriment. In hay and grass the same nutritive substances are present as in meal and flour, but in less quantity. As, however, the digestive organs of man are not in a condition to extract the small quantity of the useful from the great excess of the insoluble, we submit, in the first place, these substances to the powerful digestion of the ox, permit the nourishment to store itself in the animal's body, in order in the end to gain it for ourselves in a more agreeable and useful form. In answer to our question, therefore, we are referred to the vegetable world. Now when what plants take in and what they give out are made the subjects of investigation, we find that the principal part of the former consists in the products of combustion which are gene-

* See "The Steam-engine and the Human Body compared," in *Things not generally Known*, First Series, page 68.

rated by the animal. They take the consumed carbon, given off in respiration as carbonic acid, from the air, the consumed hydrogen as water, the nitrogen, in its simplest and closest combination, as ammonia ; and from these materials, with the assistance of small ingredients which they take from the soil, they generate anew the compound combustible substances, albumen, sugar, oil, on which the animal subsists.

Here, therefore, is a circuit which appears to be a perpetual store of force. Plants prepare fuel and nutriment, animals consume these, burn them slowly in their lungs ; and from the products of combustion the plants again derive their nutriment. The latter is an eternal source of chemical, the former of mechanical, forces. Would not the combination of both organic kingdoms produce the perpetual motion ? We must not conclude hastily. Further inquiry shows that plants are capable of producing combustible substances only when they are under the influence of the sun. A portion of the sun's rays exhibits a remarkable relation to chemical forces,—it can produce and destroy chemical combinations ; and these rays, which for the most part are blue or violet, are called, therefore, chemical rays. We make use of their action in the production of photographs. Here compounds of silver are decomposed at the place where the sun's rays strike them. The same rays overpower in the green leaves of plants the strong chemical affinity of the carbon of the carbonic acid for oxygen, give back the latter free to the atmosphere, and accumulate the other, in combination with other bodies, as woody fibre, starch, oil, or resin. These chemically active rays of the sun disappear completely as soon as they encounter the green portions of the plants ; and hence it is that in Daguerreotype images the green leaves of plants appear uniformly black. Inasmuch as the light coming from them does not contain the chemical rays, it is unable to act upon the silver compounds.

Hence a certain portion of force disappears from the sunlight, while combustible substances are generated and accumulated in plants ; and we can assume it as very probable that the former is the cause of the latter. It must, indeed, be remarked, that we are in possession of no experiments from which we might determine whether the *vis viva* of the sun's rays which have disappeared corresponds to the chemical forces accumulated during the same time ; and as long as these experiments are wanting, we cannot regard the stated relation as a certainty. If this view should prove correct, we derive from it the flattering result, that all force, by means of which our bodies live and move, finds its source in the purest sunlight ; and hence we are, in point of nobility, not behind the race of the great monarch China, who heretofore alone called himself son of the sun.

But it must also be conceded that our lower fellow-beings, the frog and leech, share the same æthereal origin, as also the whole vegetable world ; and even the fuel which comes to us from the ages past, as well as the youngest offspring of the forest, with which we heat our stoves and set our machines in motion.—*Prof. Helmholtz on the Interaction of Natural Forces.*

SCIENCE AND ITS APPLIERS.

In many fields of human exertion, the tasks of purely scientific research and of the subsequent applications of art have lain very much with different parties. It was not, for example, the chemist who first showed a jet of coal-gas burning in his laboratory who also first conceived and accomplished the noble feat of lighting up with gas a whole city, so as almost to make night there appear the day. It was not the persons who, ages ago, observed the expansive force of steam, and its sudden collapse again into water when cooled, who thought of turning steam-force to profitable use ; for it was left to James Watt, almost in our own day, to devise the present steam-engine, which has quickly spread a newer and higher civilisation over the earth. And then for many a day was the fact widely known that a shock of electricity travelled along a wire with the speed of lightning before Wheatstone and others, who still live among us, had constructed the electric telegraph, which, with the speed of lightning, can deliver at any distance, and can either write down or print the words of a message committed to it.

Real philosophers may, however, be considered to have done much by their own inventions for the useful arts. Thus the chemical or mechanical manufacturer has merely applied what the philosopher has made known ; he has merely worked up the materials furnished to him. The chlorine, or oxymuriatic gas, of Scheele was scarcely known before it was applied by Berthollet to bleaching ; scarcely was muriatic gas discovered by Priestley, when Guyton de Morveau used it for destroying contagion. Platinum owes its existence as a useful metal entirely to the labours of an illustrious chemical philosopher. Look at the beautiful yellow afforded by the metal chrome ; consider the medical effects of iodine ! We have no history of the manner in which iodine was rendered malleable ; but we know that platinum could only have been worked by a person of the most refined chemical resources. But such results are not uniform. “The production of chloroform is amongst the most subtle experimental results of modern chemistry. The blessed effects of its proper exhibition in the diminution of the sum of human agony are indescribable. But that divine-like application was not present to the mind of the scientific chemist who discovered the anæsthetic product any more than was the gas-

that our lower fellow-beings have an ethereal origin, as also the fuel which comes to us from the remotest offspring of the forest. We set our machines in motion by the action of Natural Forces.

TO ITS APPLIERS.

In exertion, the tasks of the subsequent applications to different parties. It was not until it showed a jet of coal-gas that it was conceived and accomplished to light a whole city, so as to save day. It was not the person who gave force of steam, and its own cooled, who thought of its application; for it was left to James Watt to improve the present steam-engine, and higher civilisation over the world was the fact widely known. It was along a wire with the system of Morse and others, who still live, that the electric telegraph, which, with its power to deliver at any distance, and carry words of a message committed to it, may, however, be considered to be a convention for the useful arts. The manufacturer has merely to make known; he has merely to give to him. The chlorine, or oxygen, was scarcely known before it was applied. Morveau used it for destroying the existence as a useful metal of the precious chemical philosopher. It was used by the metal chrome; and the! We have no history of the metal rendered malleable; but we have been worked by a person of resources. But such results of the action of chloroform is amongst the fruits of modern chemistry. The diminution in the diminution of the metal is a valuable. But that divine-like product of the mind of the scientific chemist is a product any more than was

lit town to the mind of Priestley, or the condensing engine to that of Black."—*Prof. Owen.*

OPPOSITION TO SCIENTIFIC IMPROVEMENTS.

Almost all the great modern improvements in the arts of life have been received with ridicule at first, and then with more active resistance—as in the cases, for instance, of agricultural implements worked by steam, of steam machinery for spinning and weaving, of gas-lighting, railways, steam navigation, the penny postage, and so forth. By such opposition as this the full introduction of Watt's steam-engine was retarded for many years, and the inventor had to defend his patent-rights by repeated appeals to courts of justice. But sometimes even enlightened and upright men have been slower than might have been expected to acknowledge the merit in new inventions, partly from caution, taught them by seeing the mass of crudities and absurdities constantly pressed on public attention as improvements by ignorant or foolish projectors, and partly because sufficient evidence of the worth of the new proposal was not yet before them. For instance, such distinguished men as Davy, Wollaston, and Watt at first gave an opinion that coal-gas could never be safely applied to the purpose of street-lighting. Others said that steam-ships would never be able safely to navigate the great ocean. When Dr. Desaguliers and Dr. Hales, about a century ago, before oxygen was known, or the nature of gases generally was understood, still judged aright of the importance of pure air to health and life, and proposed to ventilate houses or ships by mechanical means of certain or unfailing action, instead of by the agency of the inconstant wind entering windows, ports, or wind-sails, they were regarded by some honest persons in authority as erring visionaries. A curious fact belonging to this class of occurrences, and recorded by the writers of the time, was that, after Dr. Harvey published his great discovery of the Circulation of the Blood, no medical man who had then reached the age of forty ever avowed his belief that Harvey was right.—*Dr. N. Arnott.*

ALL THE OXYGEN IN THE WORLD.

Let us for an instant contemplate (says Faraday, in his *Lectures on the Non-metallic Elements*) the enormous amount of Oxygen employed in the function alone of respiration, which may be considered in the light of a slow combustion. For the respiration of human beings, it has been calculated that no less than one thousand millions of pounds of oxygen are required daily; and double that quantity for the respiration of animals; whilst the processes of combination and fermentation require one thousand millions of pounds more. But at least double

the whole preceding quantity, that is to say, twice four thousand millions of pounds of oxygen, are calculated to be necessary altogether, including the amount for the never-ceasing functions of decay. In tons it corresponds with no less than

7,142,857 in a day ;
2,609,285,714 in a year ;
280,928,571,400 in a century ;
15,655,744,284,000 in 6000 years ;

Whole quantity, 1,178,158,000,000,000.

Such being the daily requisition of oxygen in the economy of nature, how great must be the quantity existing in the world ! Why, between one-half and two-thirds of the crust of this globe and its inhabitants are composed of oxygen.

CONDENSATION BY SURFACES.

Every porous body—rocks, stones, the clods of the fields, &c.—imbibes air, and therefore oxygen. The smallest solid molecule is thus surrounded by its own atmosphere of condensed oxygen ; and if in the vicinity other bodies exist which have an affinity for oxygen, a combination is effected. When, for instance, carbon and hydrogen are thus present, they are converted into nourishment for vegetables—into carbonic acid and water. The development of heat, when air or watery vapour is absorbed, or when the earth is moistened by rain, is acknowledged to be the consequence of this condensation by the action of surfaces.—*Liebig.*

WHAT IS OZONE ?

The allotropic, or “other” condition of oxygen, replies Professor Brande. By means of a delicate test, first proposed by M. Schönbein, the discoverer of ozone, we can readily detect its presence even when it exists in very small quantities. This test is paper imbued with a solution of iodide of potassium and starch. If a slip of this paper be taken near the sea-shore, moistened with water, and exposed for a few seconds to the air, when a breeze is blowing from the land, no evident change ensues. If, however, the breeze is blowing in the opposite direction, from the sea towards the land, then the paper, originally white, assumes a tinge of blue ; thus proving the operation of a certain atmospheric influence or agent, which we shall find hereafter to be ozone. It may be generated from phosphorus and water, and by other methods. One must not, however, be passed over, inasmuch as a great portion of the ozonised oxygen existing in nature is, in all probability, referable to it—namely, *electricity*. All electrical experimenters must have noticed the odour from an electric machine in action. Not the air in the bottle, or from the phosphorus and water,

ozone, is so similar in smell as to create a possibility that the electrical odour is immediately referable to ozone; and the test-paper of Schönbein, if exposed to electric sparks, or electric pencils emanating from a point, becomes in like manner tinged blue. The connection thus established between electricity and ozone points to a fertile source of this most remarkable agent in nature. We now see the theory of the old process of bleaching by exposure to atmospheric influences,—why the operation was more successful at certain times than at others; why certain localities were especially adapted for it; and why the operation proceeded with increased rapidity after the occurrence of thunder-storms.

HYDROGEN.—THE LIGHTEST MATTER.

Even now, says Professor Brande, we are justified in hypothetically regarding hydrogen as a gaseous *metallic body*; water as a *metallic oxide*. Hydrogen gas is the lightest ponderable matter known. Dobreiner considers it to be a metal dissolved in caloric.

In 1849, M. Van Alsten, of Rotterdam, made the experiment on his own person of testing to what degree a man might, without danger, inhale hydrogen gas; when, in spite of all the exertions of his physicians, he died in a few hours.

MERCURIAL ATMOSPHERE.

It had long been admitted that in the upper part of the thermometer and barometer an atmosphere of mercury existed having a very small degree of tension, when Mr. Faraday showed, by the following simple experiment, that a mercurial atmosphere may exist without removing the air. A small portion of mercury was put through a funnel in a clean, dry bottle capable of holding six ounces, and formed a stratum at the bottom not one-eighth of an inch in thickness; particular care being taken that none of the mercury should adhere to the upper part of the inside of the bottle. A small piece of gold-leaf was then attached to the under part of the stopper of the bottle, so that, when the stopper was put in its place, the leaf-gold was enclosed in the bottle. It was then set aside in a dark and cool place, and left for six or eight weeks; at the end of which time the leaf-gold was found whitened by the mercury, though every part of the bottle and the mercury remained apparently just as before. This experiment was repeated several times, showing the mercury to be always surrounded by an atmosphere of the same substance.

WATER ANCIENTLY AN ELEMENT.

Water was considered to be an element by the ancients,

an opinion which has been thought to be unreasonable and ridiculous by some ; but (says Faraday), for me, I confess my inability to see how the ancients, with the amount of evidence at their disposal, could have arrived at any other conclusion. Viewed in its relation to the universe,—to its great natural manifestations,—to the large range of substances into which it enters,—to the manifold purposes it subserves,—and, more than all, viewed in relation to its intimate connection with living forms,—water does seem to present to our minds the leading qualities of an element ; and it is only by the aid of chemical analysis that we prove the idea to be incorrect. Consider how widely water is distributed throughout nature,—how numerous are its functions,—how tremendous its operations,—and yet how mild, how bland, how seemingly powerless this wonderful liquid is ! Let us view it in relation to the structure of living beings, and reflect how intimately it seems connected with vitality. Not only does it bathe the most delicate tissues and organs with impunity, but it enters largely into the composition of all organised forms. No structure of corporeal vitality is without it as an essential element. Water constitutes at least nine-tenths by weight of our own bodies, entering into the very bones ; yet this is but a trifling fraction of the amount of water entering into the structure of certain lower animals. Look at those delicate sea beings the medusæ, and reflect upon the vast amount of water which their structures contain ! Pellucid almost as the ocean in which they dwell, these creatures float about in the full vigour of life ; yet one may safely say that the medusæ consist of no less than nine hundred and ninety-nine parts water ! Water in this great amount pervades their whole economy. Without much violence to language, we might call them living forms of water ! Yet these same medusæ, taken from the ocean and scattered on the beach, exposed to the influence of sun and air, their aqueous portion gone, what are the medusæ then ? Shadows almost—a substance barely—the merest shred of filament and membrane !

THE COMPOSITION OF WATER.

The celebrated experiment by which it was proved that Water is composed of oxygen and hydrogen deprived of part of their latent heat, was suggested by the following circumstances. In the year 1776, Volta fired inflammable air by a simple electric spark. In 1776-7, Macqueer burned mixtures of inflammable air and oxygen in glass vessels, and observed that the part of the saucer which the flame licked was moistened with small drops of a liquor as clear as water, and which appeared to him to be pure water. Macqueer, however, drew no

conclusion from his experiments ; and it was not till some time before the 18th of April 1781 that a similar experiment was made by Priestley and Waltire, a lecturer on chemistry at Birmingham, who fired a mixture of common and inflammable airs, and of inflammable air and oxygen, and *observed a deposit of water on the side of the vessel*. Priestley further says : “ In order to judge more accurately of the quantity of water so deposited, and to compare it with the weight of the air decomposed, I carefully weighed a piece of filtering-paper, and then having wiped with it all the inside of the glass vessel in which the air had been decomposed, weighed it again, and *I always found, as nearly as I could judge, the weight of the decomposed air in the moisture acquired by the paper.*”

We have not space to enter into the controversy respecting the Composition of Water, i.e. whether it was discovered by Watt or Cavendish. According to the statement of the Rev. W. Vernon Harcourt, Cavendish's final experiment—so contrived as to enable him to consume a large quantity of the gases, sufficient to prove that the fluid condensed was pure water—was made on one of the latter *Sundays* of July 1781 : thus completely establishing the general fact of the composition of water.

The following details of the great analysis, made a few years later, are very interesting :

Fourcroy, Vauquelin, and Seguin commenced, on the 13th of May 1790, an experiment on a very large scale to prove the composition of water, and finished their labours on the 22d of the same month. The hydrogen was produced from zinc, which, after being melted, had been rubbed to a powder in a hot mortar, and strong oil of vitriol diluted with seven times the quantity of water. The gas was then passed through caustic potash to clear it from any impurities. The oxygen was obtained by heating chlorate of potassa, and was purified in a similar manner.

The hydrogen used in the experiment was 25,963·568 cubic inches, weighing 1039·358 grains ; and the oxygen 12,570·942 cubic inches, weighing 6209·869 grains. The combustion of the gases was continued for 185 hours without intermission, and the apparatus was not quitted for a moment, the experimenters resting themselves in the laboratory alternately when fatigued. The result was, that 7244 grains of water were procured, showing a loss of only five grains, or $\frac{1}{1448}$ of the whole.

In a glass jar put a mixture of two parts by measure of hydrogen with one of oxygen ; the two gases will remain calm, tranquil, quiescent ; transparent and colourless as the atmosphere itself ; they give no indication of their power. But a most extraordinary force is there, which force, if we reduce to a certain standard of comparison,—and such standard is not wanting,—will be found to equal the power of many thunderstorms. To exemplify this, fill a bag with the mixed gases, and then blow some soap-bubbles, to which apply a lighted taper,

when the result will be a violent explosion. In this result we have the evidence of tremendous power. But the result of the explosion is water—*nothing but water*. To me (says Faraday), the whole range of natural phenomena does not present a more wonderful result than this. To think that these two violent elements, holding in their admixed parts the power of whole thunder-storms, should wait indefinitely until some cause of union be applied, and then furiously rush into combination, and form the bland unirritating liquid water, is to me, I confess, a phenomenon which continually awakens new feelings of wonder as often as I view it. Or, if we place in a globe oxygen and hydrogen gases in the exact proportions in which they combine to form water, they remain without change of state, but appear to mix intimately. The moment, however, that an incandescent body, or the spark from an electric machine, is brought into contact with the mixed gases, they ignite, explode violently, and combine to form water. When hydrogen gas is allowed to flow on the surface of spongy platinum, the pores of which contain condensed oxygen, water is formed by the combination of the two gases, heat is developed, and the platinum becoming red-hot, the jet soon takes fire.

HARD AND SOFT WATERS.

Dr. Lander Lindsay uses the term *hard waters* to indicate waters containing an easily appreciable amount of neutral salts, especially of the carbonates, sulphates, and chlorides of lime and magnesia. Under this head a large proportion of spring waters is to be classed. The term is employed in contradistinction to that of *pure* or *soft* waters, which either contain no saline ingredients, or a very small proportion: such are rain, snow, and many river waters. There is frequently great difference of opinion between professional and non-professional persons as to what is, or constitutes, *hard* or *soft* water. A water was reported upon by the analyst, an English chemist of repute, as "*very soft*;" while the user of the water, a lady of great intelligence and experience, described it to Dr. Lindsay as decidedly *hard*.

Professor Christison considers a water *soft* which contains less than $\frac{1}{1000}$ part of its weight of saline ingredients; *hard* if it contains more than $\frac{1}{1000}$; *mineral* if more than $\frac{1}{1000}$. *Soft* water has the property of forming a lather with soap, and it is suitable for washing purposes, neither of which properties does *hard* water possess.

WATER TEST.

The chemical property possessed by soap, of readily dissolving in alcohol, renders the solution a valuable qualitative test

discriminating approximately the presence or absence of metallic bases in water. If an alcoholic solution of soap be poured into distilled water, no perceptible change ensues; but if the same solution be poured into any ordinary variety of natural terrestrial water, a certain amount of turbidity results, according to the amount present of earthy or metallic bases: hence, by this test, the comparative softness or hardness of different waters may be rendered evident.

FILTERING WATER.

In a lecture recently delivered at the Royal Institution, Dr. Lankester insisted upon the necessity for filtering all water used in drinking or cooking, from whatever source; and proved to his audience, by chemical analysis, that unfiltered water, however clear and bright, may contain the most deleterious if not the most deadly constituents. The lecturer the more impressively substantiated the fact by the analysis of the water from a notoriously favourite pump. The water was quite cool, fresh, and tasteless to the palate, owing to a peculiar combination of nitric acid; but, upon chemical tests being applied, it yielded a large amount of deleterious matter.

NITROGEN.

Nitrogen is a permanently elastic gas, a little lighter than atmospheric air, but fourteen times heavier than hydrogen; it has neither smell, taste, nor colour; it is not absorbable by water, and neither supports combustion nor respiration. All burning bodies are immediately extinguished when plunged into this gas, and so is animal life: it appears to kill, not by any direct chemical action upon the blood, as is the case with almost all noxious gases, but simply by the exclusion of oxygen, preventing the throwing off of carbonic acid; so that animals are rather stifled by nitrogen, as they are by suffocation or drowning, than absolutely poisoned. Now from all these illustrations, it will be obvious that the characters of nitrogen are preëminently of a negative description: it appears as a very *indifferent* body. Not so, however, when in chemical combination; for nearly all its compounds are preëminently active and energetic: powerful acids, acrid alkalies, intense poisons, violent detonators, are amongst them. Nitric acid, ammonia, and cyanogen belong to this class; they are binary compounds of nitrogen: all the most dangerous fulminators contain it as one of their essential elements; gunpowder cannot be made without it; in short, whether we look at nitrogen under these simpler forms of combination, which, to a certain extent, may be commanded by art, or under those more complicated relations

which can only be called into existence by vital functions, we find its chemical history full of instructive and important details.—*Brande's Lectures.*

SERVICES OF NITROGEN IN THE ATMOSPHERE.

These are very important. Nitrogen, as the chief constituent in weight and bulk of the atmosphere, diminishes the rapidity of combustion and oxidation at the earth's surface; whilst as a great gaseous envelope, which the ocean and tributary waters cannot dissolve, and which neither acts injuriously on rocks, plants, or animals, nor is altered in quality by them, it forms a permanent medium for the production of winds, and a moderator and equaliser of the sidereal light; heat, and other agencies determining climatic differences, such as no other gas, simple or compound, known to us could be.—*Dr. G. Wilson.*

NITROGEN AND GUN-COTTON.

"Nitrogen," says Gmelin, "has probably the greatest affinity of all ponderable bodies for heat, with which it constantly tends to form a gas. Consequently, many of its compounds are decomposed by slight causes, and with extreme suddenness, the nitrogen being disengaged in the gaseous form, and often producing the most violent explosions." Thus it confers explosiveness on its compounds, as in gunpowder; the various bodies of which Gun-cotton is the type; percussion-cap powder, and other fulminates; the so-called ammoniuret of gold; and the chloride and iodide of nitrogen.

In a greatly lessened degree, this chemical fragility and instability are conferred by nitrogen upon the compounds which it forms with living organisms. The immensely greater and more numerous chemical changes which characterise animals than plants are essentially connected with the greater abundance of nitrogen in the former. The difference between the slightly alterable, slowly combustible vegetable cotton, a compound of carbon, hydrogen, and oxygen, and the spontaneously decomposable explosive Gun-cotton, which differs from it in quality of ingredients by the addition of nitrogen, is typical of the distinction between the enduring non-nitrogenous vegetable compounds, and the spontaneously changeable nitrogenous animal compounds; although, in this particular case, the increase of oxygen in the Gun-cotton exaggerates the instability to the point of explosion.

The simplest process of making Gun-cotton consists in dipping the fibre (which must be perfectly clean) into strong nitric acid, allowing the acid to saturate it thoroughly, then finally

removing the cotton-fibre, washing it until every trace of acid is separated, and drying it at a temperature under 100°. Practically, however, it is found desirable to mix a little sulphuric acid with the nitric acid, for the purpose of strengthening the latter, which it accomplishes by its affinity for water.

Gun-cotton, although still resembling ordinary cotton to the naked eye, feels different, and presents a different aspect when examined microscopically.

The composition of Gun-cotton has not been accurately determined, nor are chemists agreed as to the rational formula by which it may be represented. We must therefore rest satisfied with regarding it as a combination of nitric acid, or of nitrous acid with lignine, or modified lignine, in which the latter performs the part of a base. (*Brande's Lectures.*)

In an experiment performed in Schönbein's laboratory at Basle, a certain weight of gunpowder, when fired, filled the apartment with smoke; whilst an equal weight of Gun-cotton exploded without producing any smoke, leaving only a few atoms of carbonaceous matter behind. Balls and shells were experimentally projected by this prepared Cotton, which was stated to have nearly double the projectile force of gunpowder; in proof of which Schönbein experimented upon the wall of an old castle near Basle. It had been calculated that from three to four *pounds* of gunpowder would be requisite to destroy this wall, and a hole to contain that quantity was prepared. In this aperture were put four *ounces* of the prepared cotton, which, when fired, blew the massive wall to pieces.

Again, the sixteenth of an ounce of the Cotton, placed in a gun, carried a ball through two planks at the distance of 28 paces; and, with the same charge and distance, drove a bullet into a wall 3½ inches. A dram of the cotton also sent a ball, ½oz. weight, to a distance of 200 paces, where it penetrated a deal plank to the depth of two inches. A portion of this cotton, when thrown into water, and afterwards dried, did not lose its inflammable property. Such were the earliest experiments made by Schönbein, the inventor, in Switzerland.

Gun-cotton was used for the first time in actual warfare at the siege of Moultan in the East Indies; when the brilliance and breadth of the flash of the guns fired by this new adaptation of science to the devastation of war are described to have been of terrific intensity.

But the new compound has other uses. Gun-cotton is soluble in ether, and a compound is formed, to which the name of *collodion* has been given. This substance has been found of the greatest use in many of the arts, especially photography. On being exposed to the air, the ether evaporates, leaving behind a thin transparent film, which is applied to wounded sur-

faces instead of goldbeaters' skin. It may also be made into delicate bags, into which hydrogen may be introduced for balloons. In photography, the collodion is mixed with the iodides to be acted on by light; and being spread on glass, pictures, from which any number of impressions may be taken, are produced.

Although the British Board of Ordnance have decided against the adoption of this explosive compound in the military and naval services, its advantages have been differently appreciated on the Continent, the Austrian government having presented Professor Schönbein with the sum of 2500*l.* as a reward for his invention.

A new kind of Gun-cotton has been prepared in the United States, by treating newly-prepared Gun-cotton with a saturated solution of chlorate of potash. A pistol loaded with one grain of this cotton has sent a ball through a yellow pine door one inch thick, at the distance of 20 feet.

Many circumstances conspire to prevent the application of Gun-cotton to the purposes of gunnery. Its velocity of combustion is too great for all fire-arms, save those of the strongest make and smallest bore. Its strength is subject to variation, not only from the operation of atmospheric causes, such as the absorption of moisture, but from spontaneous decomposition; the latter agency reducing Gun-cotton, after a certain time, to the original condition, or ordinary combustibility, of native cotton. The physical conditions of a fibrous body, moreover, are very much opposed to the employment in fire-arms of Gun-cotton. Other objections are those of ignition from percussion, or even spontaneously, and the acid fumes (although no smoke) evolved by Gun-cotton undergoing combustion. Its employment as a blasting agent in mines promised greater success; its freedom from smoke being a great advantage to the miner. Unfortunately, however, the use of Gun-cotton has been discontinued even for this purpose, chiefly on account of the danger attending its manufacture, and its liability to explode from the operation of very slight causes.

PRUSSIC ACID.

In the bicarburet of nitrogen, termed cyanogen, we have an extraordinary example of the indirect manner in which certain compositions are effected, no less than of the wonderful change of properties which results. Carbonic acid, although poisonous under certain circumstances, is concerned in the ever-occurring function of respiration, bathing unharmed the air-cells of the lungs, remaining in contact with the most delicate tissues, yet producing no evil result: nitrogen, too, is endowed with a similar negative quality, this element constituting

no less than four-fifths of our atmosphere, which we breathe, almost unconsciously, without intermission from our birth to our death. Yet such is the strange effect of combination, that nitrogen, when united with carbon in the ratio of fourteen parts by weight to twelve, gives rise to a peculiar gaseous substance termed cyanogen, which, if breathed only in small quantities, proves fatal at once, and which, by union with hydrogen, constitutes that terrible—most terrible perhaps of all poisons, Prussic acid. The odour of cyanogen is that of peach-blossoms, and when burned it evolves a peculiar rose-coloured flame, which is very distinctive of this gas.

HOW SIR HUMPHRY DAVY BREATHED NITROUS OXIDE.

Davy, for this investigation, devised the very beautiful method of procuring the nitrous air, viz. the decomposition by heat of the crystals of nitrate of ammonia, which are thereby dissolved into watery vapour and the desiderated gas. Under the famous name of nitrous oxide, he minutely examined and recorded its properties for the first time. In his *Researches* he tells us :

Having previously closed my nostrils and exhausted my lungs, I breathed four quarts of nitrous oxide from and into a silk bag. The first feelings were similar to giddiness ; but in less than half a minute, the respiration being continued, they diminished gradually, and were succeeded by a sensation analogous to gentle pressure on all the muscles, attended by a highly pleasurable thrilling, particularly in the chest and the extremities. The objects around me became dazzling, and my hearing more acute. Towards the last inspiration the thrilling increased, and at last an irresistible propensity was indulged in. I recollect but indistinctly what followed : I know that my motions were various and violent. These effects very soon ceased after respiration, in ten minutes I had recovered my natural state of mind. Almost every one who has breathed this gas has observed the same thing. On some few, indeed, it has no effect whatever, and on others the effects are always painful. The experiment cannot be made with impunity by those who are liable to determination of blood to the head.

Davy was at first sanguine of the useful application of nitrous oxide to medicine. It might be the Potable Gold of Geber, the vivifying quintessence of the Elements of Raymond Lully, the Water of Life of Basil Valentine, the Elixir of Paracelsus, at least some purified and attempered supporter of vitality, for its composition was almost identical in its ingredients with that of the atmosphere. But Davy soon discovered his mistake, recorded its inutility, and pointed out the fallacies attendant on the trial of so strange and novel a medicinal agent.

SULPHURING WINE-CASKS.

The rationale of this familiar process is as follows : when

the sulphur is burned in the wine-casks, the oxygen taken up by the wine from the air during the filling of the casks is seized by the sulphurous acid, whence the formation of vinegar is thus prevented, and the wine is insured from acidity.

STORES OF CARBON IN COAL-FIELDS.

Calculation shows that the present amount of atmospheric carbonic acid is sufficient for keeping up the large amount of carbon which vegetables require. But the question has been mooted, whether an atmosphere containing no more carbonic acid than at present could have been reasonably assumed to have furnished that enormous amount of Carbon which is stored away in our Coal-fields. Probably, it is assumed, the atmosphere in that early period of the world, when coal-fields were deposited, contained more carbonic acid than it does at present; but for the greater number of vegetable species an atmosphere charged with any considerable amount of carbonic acid over and above that supplied to us is fatal. As regards the fern tribe, however, they have been proved by experiment to be capable of living and thriving in an atmosphere containing an amount of carbonic acid fatal to other species. Now the fact is well known that coal-fields are chiefly made up of the remains of gigantic ferns; and hence we recognise the exercise of a wise forethought in so adapting the organism of these vegetables that they could live and flourish in an atmosphere of carbonic acid which would be fatal to most other vegetables and the higher order of animals.—*Faraday*.

CAOUTCHOUC AND CAOUTCHOUCINE.

The following simple experiments pleasingly illustrate the properties of India rubber, or Caoutchouc, and the spirit distilled from it, named Caoutchoucine.

Put a little ether into a bottle of Caoutchouc, close it tightly, soak it in hot water, and it will become inflated to a considerable size. These globes may be made so thin as to be transparent. A piece of caoutchouc the size of a walnut has thus been extended to a ball fifteen inches in diameter; and a few years since a Caoutchouc balloon thus made escaped from Philadelphia, and was found 130 miles from that city.

Dissolve a small piece of Caoutchouc in a little Caoutchoucine, and put a drop or two of the solution upon a looking-glass or window-pane; touch it lightly with a dry piece of India rubber, quickly draw out a fine thread, which attach to a card, and wind off as silk.

Put Caoutchoucine into a phial, little more than sufficient to cover the bottom, and the remainder of the phial will be

filled with a heavy vapour ; pour this off the spirit into another phial ; apply to it a piece of lighted paper, and the vapour will burn with a brilliant flame.

IDENTITY OF THE DIAMOND AND CARBON.

That Diamond is simple Carbon (not charcoal) is shown by the following experiment. M. Morveau exposed to intense heat a diamond shut up in a small cavity in a piece of tough iron. When he opened the cavity, the diamond was entirely gone, and the iron around it was converted into steel. This shows that it is pure carbon, which combines with iron to form steel ; and not charcoal, which is generally an oxide of carbon. In 1815, Mr. Children converted iron into steel by union with diamond, under the sole action of a large voltaic battery.

The combustion of the Diamond is effected by holding the gem by a little platinum clamp and igniting it to whiteness in the oxyhydrogen flame ; and then plunging it, while incandescent, into a jar of oxygen. Eventually the resulting gas is proved, by means of the lime-water test, to be carbonic acid.

Diamonds which have been exposed under peculiar conditions to an intense heat may be seen to have lost their crystalline aspect—to have *opened out*, forming a cauliflower-like excrescence, and to have assumed the aspect of coke. Such specimens are most curious, as furnishing us with a striking instance of allotropism—that mysterious existence of identical matter in two states.

The only chemical difference perceptible between Diamond and the purest Charcoal is the hydrogen contained in the latter, which is, in some cases, less than $\frac{1}{1000}$ part of the weight of the substance. Mr. Smithson Tennant and Dr. Ure, however, considered Diamond to differ from the usual form of Charcoal only by its crystallised form.

Sir Humphry Davy exposed charcoal to intense ignition *in vacuo*, and in condensed azote, by means of Mr. Children's magnificent battery, when it slowly volatilised, and gave out a little hydrogen. The remainder was always much harder than before, and in one case so hard as to scratch glass, while its lustre was increased. This fine experiment may be regarded as a near approach to *the production of the diamond* (see also the accounts of the Diamond in *Things not generally Known*, pp. 200-203 ; *Popular Errors Explained and Illustrated*, pp. 55-56).

The composition of this gem is undoubtedly carbon, seeing that the sole result of its combustion in oxygen is carbonic-acid gas ; but the origin of the Diamond is a subject of much curious speculation. Seeing that its structure is crystalline, the Diamond should have been, at some early period, in a liquid

or semi-liquid condition, a state which presupposes fusion by fire, or solution in some menstruum. Opposed to the first hypothesis is the circumstance that within the structure of many Diamonds are seen the remains of organic beings, appearances scarcely consistent with the assumption that the Diamond was once in a state of igneous liquidity. Sir David Brewster inclines to the opinion that the Diamond is a drop of fossilised gum.—*Faraday*.

FORMATION OF DIAMONDS.

The establishment of the identity of Carbon and the Diamond soon led persons to anticipate the time when our home manufactures should rival the produce of Golconda. In such speculations it is but reasonable to take into account the reflection with which Mrs. Somerville closes the following passage: "It had been observed that when metallic solutions are subjected to galvanic action, a deposition of metal, generally in the form of minute crystals, takes place on the negative wire. By extending this principle, and employing a very feeble voltaic action, M. Becquerel has succeeded in forming crystals of a great proportion of the mineral substances, precisely similar to those produced by nature. The electric state of metallic veins makes it possible that many natural crystals may have taken their form from the action of electricity bringing their ultimate particles, when in solution, within the narrow sphere of molecular attraction, which is the great agent in the formation of solids. Both light and motion favour crystallisation. Crystals which form in different liquids are generally more abundant on the side of the jar exposed to the light; and it is a well-known fact that still water, cooled below thirty-two degrees, starts into crystals of ice the instant it is agitated. Light and motion are intimately connected with electricity, which may therefore have some influence on the laws of aggregation: this is the more likely, as a feeble action is alone necessary, provided it be continued for a sufficient time. Crystals formed rapidly are generally imperfect and soft; and M. Becquerel found that even years of constant voltaic action were necessary for the crystallisation of some of the hard substances. If this law be general, *how many ages may be required for the formation of a Diamond?*"

Simmler suggests that Diamond may possibly be a product of crystallisation from liquid carbonic acid. Diamond often contains cavities; and, as Sir David Brewster has observed, with accompanying circumstances which point to a strong pressure in the interior, although he does not state whether they contained water.

Brewster explained his observations of the coloured rings

with the black cross around the cavities by ascribing to the diamond a gummy consistence and vegetable origin. Simmler suggests that it may rather be compared to that of unequally compressed glass.

To confirm this view of the formation of diamonds, it would be necessary to prove that liquid carbonic acid possessed a solvent power for carbon similar to that which bisulphide of carbon has for sulphur, or liquid sulphide of phosphorus for phosphorus. Experiments which Simmler made in this direction, with a view of preparing liquid carbonic acid by Faraday's method, gave no results, as the tubes always exploded.—*Philosophical Magazine*, No. 114.

The old notion that "Diamonds grow" has lasted to our own time. When Dr. Buchanan visited the diamond-mine of Panna in India, the workmen assured him, "that the generation of diamonds is always going forward, and that they have just as much chance of success in searching earth which has been fourteen or fifteen years unexamined as in digging what has never been disturbed; and, in fact, he says, I saw them digging up earth which had evidently been before examined." M. Voysey, who visited some of the principal diamond-mines of Southern India in 1821, confirms the statement of Dr. Buchanan, that the diamonds are supposed to grow in the old rubbish that had been previously examined. Nay, the truth of this opinion may be considered as demonstrated by the fact, that the miners no longer quarry fresh breccia from beneath the sandstone, but "are content with sifting and examining the old rubbish of the mines," and in which they actually find diamonds. The opinion that diamonds grow in the previously washed, sifted, and examined rubbish, and that the chips and small pieces rejected by former searchers actually increase in size, and in process of time become large diamonds, prevails every where in India; and even at Grani Partaal or Couloure, where the great Koh-i-noor was found, the search is confined to the rubbish of the old mines.

M. Voysey, who was geologist to the Indian Trigonometrical Survey, adds the important observation, that in hot climates crystallisation goes on with wonderful rapidity, and that he hoped at some future period to produce undeniable proofs of the recrystallisation of amethyst, zoolite, and feldspar in alluvial soil! Unfortunately for science, M. Voysey died soon after the above was printed.

NEW DIAMOND.

MM. Wohler and Deville have made experiments upon oron, from which it appears that it can exist in three states, exactly corresponding to those of carbon, viz. the amorphous,

the graphitic, and the crystallised state. In order to obtain the latter, 100 grammes ($3\frac{1}{2}$ ounces) of boric acid and eighty of aluminium are exposed, during five hours, to a violent fire in a black crucible coated with charcoal-powder. The mass is then left to cool, and on breaking the crucible, two distinct strata come to view—one consisting of vitrified Boric Acid, or Boracic Acid containing some alumina; and the other of aluminium in a metallic state, mixed up with crystals of boron. To separate the latter, this metallic mass is treated with boiling caustic soda to dissolve the metal; then with boiling hydrochloric acid to carry off the iron which may have been separated from the plumbago of the crucible; and lastly, with a mixture of nitric and hydrofluoric acid, to dissolve the silicium left by the soda. After this, the boron is obtained pure, in three varieties of crystals, viz.—1, black and opaque laminæ, which will cut diamond, though not so well as diamond-powder: 2, long prismatic crystals, perfectly transparent and as brilliant as diamonds, but not so hard as the former variety; if without flaws, they might be used for jewelry; 3, very minute but distinct crystals of a red chocolate colour, and quite as hard as diamond; they may be used as diamond-powder, and give a fine polish.

WHAT PRECIOUS STONES ARE MADE OF.

First, as to the Diamond, which, though the king and chief of all, may be dismissed in two words—pure carbon. The diamond is the ultimate effort, the idealisation, the spiritual evolution of coal—the butterfly escaped from its antenatal tomb, the realisation of the coal's highest being. Then the Ruby, the flaming red Oriental Ruby, side by side with the Sapphire and the Oriental Topaz—both rubies of different colours—what are they? Crystals of our commonest argillaceous earth, the earth which makes our potter's clay, our pipe-clay, and common roofing-slate—mere bits of alumina. Yet these are among our best gems, these idealisations of common potter's clay. In every 100 grains of beautiful blue Sapphire, ninety-two are pure alumina, with one grain of iron to make that glorious blue light within. The Ruby is coloured with chromic acid. The Amethyst is only silica or flint. In 100 grains of amethyst, ninety-eight are simple pure flint—the same substance as that which made the old flint in the tinder-box, used before our phosphorus and sulphur-headed matches; and which, ground up and prepared, makes now the vehicle of artists' colours. Of this same silica are also Cornelian, Cat's-eye, rock crystal, Egyptian Jasper, and Opal. In 100 grains of opal, ninety are pure silica and ten water. It is the water, then which gives the gem that peculiarly changeable and iridescent

colouring which is so beautiful, and which renders the opal the moonlight queen of the kingly diamond. The Garnet, the Brazilian—not the Oriental—Topaz, the Occidental Emerald, which is of the same species as the Beryl, all these are compounds of silica and alumina. But the beryl and emerald are not composed exclusively of silica and alumina : they contain another earth, called glucina—from *glukos*, sweet, because its salts are sweet to the taste. The Hyacinth gem is composed of the earth, not so long discovered, called zirconia, first discovered in that species of hyacinth stone known as zircon. The zircon is found in Scotland. To every 100 parts of hyacinth seventy are pure zirconia. A Chrysolite is a portion of pure silicate of magnesia. Without carbonate of copper there would be no Malachite in Russia or at the Burra Burra mines ; without carbonate of lime there would be no Carrara marble ; the Turquoise is nothing but a phosphate of alumina coloured blue by copper ; and the Lapis Lazuli is only a bit of earth painted throughout with sulphuret of sodium.

CARBONIC OXIDE.—CARBONIC ACID.

Professor Dumas has illustrated the great, and indeed almost unsurpassed, influence of carbonic-oxide gas. The judicial investigations in France have disclosed the fatal effects of this gas as being much greater than carbonic-acid gas. In the atmosphere produced by the burning of charcoal, $\frac{5}{11}$ part of carbonic oxide was fatal, while with one-third the volume of carbonic acid the animal was asphyxiated, but afterwards revived.

The volume or bulk of carbonic-acid gas expired by a healthy adult in twenty-four hours is said to amount to 15,000 cubic inches, containing about *six ounces* of solid carbon. This is at the rate of 137 pounds avoirdupois per annum ; and taking the total population of the globe at seven hundred and sixty millions, the amount of solid carbon or charcoal every year produced by the human race will exceed 46,482,143 tons ! Adding to this all the carbon produced by the combustion of fires and gas-lights, by the decay of animal and vegetable matter, the exhalations from springs, &c., there need be no marvel as to the source whence plants derive their solid or woody material (which is principally carbon), seeing that their leaves are specially fitted for the absorption of carbonic-acid gas from the surrounding atmosphere.

On the lowest calculation, the population of London must add to the atmosphere daily 4,500,000 pounds of carbonic acid.

It is supposed that from the enormous quantity of carbonic acid which appears from time to time in the atmosphere of the

New World, and from the large number of volcanoes that exist in the country, that a portion of the carbonic acid of the air in other countries is due to them, and that they thus contribute in part to nourish the vast and beautiful vegetation of the Tropics.

LIQUID AND SOLID CARBONIC ACID.

The means employed by the discoverer (Faraday) for reducing gases into fluids are of admirable simplicity. A simple bent tube, or a reduction of temperature by artificial means, has superseded, in his hands, the most powerful compressing engines.

When sulphuric acid is poured upon limestone in an open vessel, carbonic acid escapes with effervescence as a gas; but if the decomposition be effected in a strong, close, and suitable vessel of iron, we obtain the carbonic acid in a state of liquid.

Its properties are very curious. When a small jet of it is permitted to escape in the atmosphere, it assumes its gaseous state with extraordinary rapidity, and deprives the remaining fluid of heat so rapidly that it congeals into a white crystalline mass like snow: this is pure frozen carbonic acid, with a temperature of at least 144° Fahrenheit below that of freezing water.

When exposed to the air, nay, when thrown into a red-hot capsule, this snow-like carbonic acid retains, while continually evaporating, its solid form (in that portion which has not yet evaporated); and so long as it retains its solid form, it retains also its low temperature (its melting-point). The more rapid addition of heat hastens its evaporation, but produces no other change on the portion which remains solid.

If we handle solid, snow-like carbonic acid, we perceive but little of its intense cold, because its light, spongy, porous structure, like that of dry flakes of snow, offers very few points of contact with the skin, and hence can withdraw from it but little of its heat.

But if we press the solid acid with some force on the skin, the circulation of the blood is arrested at the point touched, as by a metal at a dull red heat; a white spot appears, which in fifteen seconds becomes a blister, and in two minutes a white depression is formed, followed by suppuration and healing, a scar being left.

The solid carbonic acid communicates to ether its very low temperature; and if the mixture be placed upon mercury, it (the metal) will become in a few minutes solid and malleable.

When the mixture of ether and solid carbonic acid is placed in the vacuum, the increased and accelerated evaporation produces so intense a degree of cold (from 180° to 200° below th-

freezing-point of Fahrenheit), that most of the compound gases become liquid when exposed to it, and several are frozen.

If you put the mixture of ether and solid carbonic acid into a red-hot crucible, it will require for its conversion into gas as much time as it would in the air at the ordinary temperature; and if you introduce into the mixture, in a vessel of ordinary temperature, or in the red-hot crucible, a small tube containing mercury, the mercury freezes and becomes solid.*

SULPHUR IN HAIR AND WOOL.

The proportion of Sulphur in Hair and Wool is very large; and as they are daily growing, they necessarily draw upon and rob the land of sulphur, its especial constituent. Professor Johnston, in his *Elements of Agricultural Chemistry and Geology*, states that the wool which is grown in Great Britain and Ireland carries off the land every year upwards of 4,000,000 of pounds of sulphur, to supply which would require the addition to the soil of 300,000 tons of gypsum. Things that appear trifling to us when viewed in the small way in which we actually see them, become important when considered in the large scale in which they take place in nature. The hair on the heads of our population carries off nearly half as much as the wool of our sheep: it is not without reason, therefore, that the Chinese collect, and employ as a manure, the hair shaven every ten days from the heads of their people.—*North British Review*, No. 6.

Professor Bailey states, in *Silliman's Journal*, that with the nitroprusside of soda he has detected the presence of sulphur in the smallest portion of coagulated albumen, horn, nails, feathers, &c. supported on a platinum-wire for blowpipe experiments; and he has often obtained the beautiful purple tint in operating upon a piece of a single fibre of the human hair less than one inch in length.

SULPHUR IN BOILED EGGS.

It is well known that silver, when brought in contact with eggs which have been heated, is blackened, and that this discoloration is owing to the sulphuret of silver. It is usually admitted that this sulphuret is formed by the action of the sulphuretted oils supposed to exist in the yolk of the egg. M. Gobley, not having found in this body any thing of this nature, has examined the causes of the phenomenon: he finds that the yolk of an egg at the common temperature, and also when heated, does not discolour silver, even by several hours' con-

* The late Sir Isambard Brunel for ten years carried on experiments in constructing a machine for using carbonic-acid gas as a motive power.

tact. He further finds that albumen, as procured from the egg, does not tarnish silver, but when heated it gives it a brown tint, which is stronger as the heat is greater. He therefore concludes that the discoloration of the silver is due to the sulphur contained in the albumen, and not to that supposed to exist in the yolk. By other experiments he has ascertained that the sulphuret thus formed is not the result of the immediate action of the sulphur upon the silver, but by the application of heat the sulphur and the alkali of the albuminous matter react upon each other so as to form a substance which is afterwards decomposed by this metal.

PHOSPHORUS.

It is now nearly two centuries since Brandt, the Hamburgh alchemist, in his search for gold, accidentally discovered the elementary body Phosphorus, named, from its property of being luminous in the dark, from two Greek words, *phos*, light, and *phero*, I bear. Within two years of this discovery, or in 1670, one Kraft brought a small piece of phosphorus to London, and showed it to Charles II. and his Queen, the year after peace was concluded with Holland. The Hon. Robert Boyle afterwards discovered the process, which he described in the *Philosophical Transactions* for 1680, and in a small work which he published in the same year, entitled the *Aerial Noctiluca*. Mr. Boyle instructed Mr. Godfrey Hankwitz of London how to procure phosphorus from urine, so that he was the first who made it for sale in England; and he is said to have supplied all Europe with it for many years. It continued long to be an expensive chemical: for in 1731 we find by the books of the Royal Society that for Dr. Frobenius's experiments on the Transmutation of Phosphorus, exhibited before the Prince of Wales, the phosphorus used on the occasion, amounting to six ounces, cost ten guineas!

Phosphorus has since been known as a dangerous combustible and most deadly poison.

Since about 1660 (says Dr. G. Wilson) we have been familiar with Phosphorus as a soft, semi-transparent, nearly colourless, wax-like substance, possessed of a glassy structure, exhaling in the air an odour of garlic, shining at the freezing-point of water, melting a hundred degrees below the boiling-point (111.5° F.) of that liquid, bursting into flame in the air at a temperature a little higher, and yielding a thick white smoke, condensing into a snow of phosphoric acid. This form of the element we have learned to distinguish as vitreous phosphorus. It is so inflammable that it can be preserved with safety only under water, and there is scarcely a chemist who has not been in some degree a martyr to its flames. It is so poisonous that not a year passes without some poor child falling a victim to the minute portion which it thoughtlessly eats from a lucifer-match, and without uncautioned lucifer-match makers suffering the prolonged torture of slow poisoning, which its

daily administration in infinitesimal doses infallibly occasions. It reacts so powerfully upon the air in which it is permitted to fume, that it changes its oxygen into the energetic, oxidising, deodorising, and bleaching agent which is known as ozone. In a word, it exhibits in an intense degree an affinity, or tendency to combine, alike with metals and non-metals, and strikingly alters each by its union with it.—*Edinburgh Essays*, 1856.

Vitreous Phosphorus is susceptible of these modifications : 1. From the glassy to the crystalline condition. 2. By exposure under water to air and light, it becomes a *white*, opaque body. 3. By fusion, heat, and sudden cooling, black and opaque. 4. By heat and sudden cooling, viscid like sulphur, and in consistence like caoutchouc. 5. An amorphous red solid.

Phosphorus, however, when prepared red, or amorphous, is much less fusible than common phosphorus. This red phosphorus is not poisonous, even when directly administered in doses a hundred times greater than those which are fatal with vitreous phosphorus ; it may be handled with impunity ; and by Schrötter's process of preparing it, the manufacture, use, and carriage of lucifer-matches made with it are much less dangerous than formerly. Messrs. Allbright, near Birmingham, have for several years prepared this red phosphorus on a large scale. The common phosphorus is derived from calcined bones, by treating them with sulphuric acid and water ; and it is rendered amorphous by exposing it for fifty hours to a temperature of about 500° in an atmosphere which is unable to act chemically upon it.

The Lucifer Match was invented in 1827, by Mr. John Walker, a chemist and druggist, of Stockton-upon-Tees. He was preparing with phosphorus some lighting mixture for his own use, when by accidental friction on the hearth of a match dipped in the mixture a light was obtained. The hint was not thrown away. Mr. Faraday, it is said, first brought the discovery into practice. Mr. Walker died in 1859, aged seventy-eight.

The *Bolognian Phosphorus*, one of the most powerful of the solar phosphoric substances, had a curious origin. It was the accidental discovery of Viscenzio Cascariolo, a shoemaker, of Bologna, who, about the year 1630, being engaged in some alchemical experiments, had occasion to calcine a quantity of active sulphate of barytes, found near Bologna at Monte Paterno. He observed that whenever this mineral had been sufficiently heated, it acquired the property of shining in the dark after having been exposed to the sun's rays, and that it would even continue thus to emit light for some hours. The best mode of preparing this substance became a subject of no small pecuniary importance, and a family of the name of Zagoni appear to have been the most successful preparers of it.

NICE ESTIMATE OF LIGHT.

Mr. Faraday and M. Becquerel, to show that fluorescence and phosphorescence are luminous conditions differing only in the *time* of their continuance, employ the *Phosphroscope*, the cylinder of which revolves 300 times in a second, showing a phosphorescent effect which lasts only the $\frac{1}{300}$, or even the $\frac{1}{600}$ of a second.

Several times Mr. Faraday has observed that a flash of lightning, when seen as a linear discharge, left the luminous trace of its form on the cloud, enduring for a sensible time after the lightning was gone; the true explanation of which Mr. Faraday considers to be the phosphorescence of the cloud.

An instrument has been constructed for producing isolated luminous impressions, varying from one-tenth to one-millionth of a second.

UBIQUITY OF IODINE.

Iodine, thus called on account of its violet colour, from the Greek word *iodos*, was accidentally discovered by M. Courtois, a manufacturer of saltpetre, at Paris, in 1812. In his process for procuring soda from the ashes of sea-weed, he found the metallic vessels much corroded, and in searching for the cause he made the important discovery.

Sir Humphry Davy tried to decompose iodine, but he failed in his subtle analysis; and to the present day iodine is considered as a simple body—one of the primitive elements of our terrestrial world.

Where do we find iodine? a little every where and in every thing, but generally a very small proportion. All the fishes, shells, sponges, and ocean weeds yield iodine; and the wrack-grass, those fuci which the boiling and rolling of the waves deposit upon the barren shores, seemed to be useless refuse, but are now known to yield a useful substance in pharmacy and the arts. Iodine has the property of dissolving the gland of goitre and cretinism, and is the principal agent in Photography.

Thus, we find evidence of the existence of iodine in marine and fresh-water aquatic plants from all quarters of the globe. Fermented liquors contain iodine: wine, cider, and perry are more ioduretted than the average of fresh waters. Milk is richer in iodine than wine; independently of the soil, with which it varies, the proportion of iodine in milk is in the inverse ratio of the abundance of that secretion. Eggs (not the shell) contain much iodine: a fowl's egg weighing fifty grains contains more iodine than a quart of cow's milk. Iodine exists in various soils. It is abundant in sulphur, and in ores of iron and manganese, and sulphuret of mercury; but rare in gypsum, carbonates of lime, and siliceous earths. Any attempt to extract iodine economically should be made from fuci. Most of the bodies regarded by the therapeutists as pectoral and antiscrofulous are rich in iodine. To sum up, M. Chatin shows that iodine has been detected in the waters of the

ocean, lakes, and springs; in the solid crust of the earth in various mineral compounds; in many plants,* chiefly, if not entirely, aquatic; in animals; as an ingredient in the earth's atmosphere, as in rain, dew, and snow. The test admits of extraordinary delicacy: Dr. Price has detected the ~~xxxxxx~~ part of iodine dissolved in water as iodide of potassium.

Iodine stains the skin, but not permanently; it has a very energetic action upon the animal system, and is much used in medicine. One of its most characteristic properties is the production of a splendid blue colour in contact with the organic principle starch.

EARLY GAS-LIGHTING.

Soon after the establishment of the first gas-works at Westminster, in 1810-12, an extensive explosion took place on the premises, when a committee of the Royal Society was, at the request of the Government, appointed to investigate the matter. They met several times at the gas-works to examine the apparatus, and made a very elaborate report, in which they stated as their opinion, that if gas-lighting was to become prevalent, the gas-works ought to be placed at a considerable distance from all buildings, and that the reservoirs should be small or numerous, and always separated from each other by mounds of earth or strong party-walls! Some sixty years before, in 1753, Sir James Lowther described to the Royal Society a curious notice of a spontaneous evolution of gas at a colliery near Whitehaven. It annoyed the workmen so much that a tube was made to carry it off. Sir James states that parties were in the habit of filling bladders with the gas, and burning it at their convenience. It appears strange that this hint did not bring gas-lighting into use earlier.—*Philos. Trans.* vol. 38. (See "Progress of Gas-lighting," *Things not generally Known*, First Series, p. 198.)

UNWHOLESOMENESS OF LIGHTS.

Recent experiments have proved that Lights of equal intensity, obtained from different materials, require very different lengths of time to generate the same quantity of carbonic acid. The following is the relative time required by common materials: Olive-oil, 72 minutes; Russian tallow, 75; common (French) tallow, 76; whale-oil, 76; stearic acid, 77; wax candles, 79; spermaceti, 83; gas from common coal, 98; gas from cannel coal, 152 minutes. Coal-gas, therefore, and especially gas from cannel coal, is the least unhealthy of all ordinary lights, which is contrary to the usual opinion.

* Nearly fifty years since, the writer remembers the pulp of sea-weed as a popular remedy for the spine and limbs of weak and rickety children, much in use at Brighton and other watering-places, long before the existence of Iodine in marine plants had become generally known.

EFFECTS OF CARBURETTED HYDROGEN ON PLANTS.

A collection of exotic plants in a green-house in Philadelphia was, through the breakage of the city "mains," and the consequent leakage of a large quantity of gas, exposed to its deleterious influence. The plants, numbering nearly 3000, were almost entirely ruined. Those in leaf did not suffer, nor did a row of maple-trees immediately over the leak; the injury sustained being entirely through their breathing organs. The general sympathy known to exist between the genera of the same natural order extends to the action of this deleterious substance upon them. The beautiful *Amantiaceæ* were so keenly sensitive to the poison that even large old specimens were stripped at once. The floor was covered with leaves, and oranges and lemons in all stages of growth, from fruit first formed to that fully matured. The trees, by careful pruning and nursing, were somewhat restored. *Camelliæ* were in full bloom, in about 120 varieties; not a leaf, bud, or flower remained upon the largest and the finest plants.

CHEMICAL EFFECTS OF INTERMENT IN VAULTS AND CATACOMBS.

Although much had been said and written on the decomposition of the human body after interment in the earth, but little was known until lately respecting the process and results of such decomposition when modified by the corpse being placed in a vault or catacomb.

In 1849 and 1850, Mr. Walter Lewis, by direction of the General Board of Health, visited the vaults of the principal churches of London, noted the external appearance of more than 22,000 coffins, and the contents of nearly 100, and several times tested or analysed the atmosphere of the vaults. In no case did he discover the slightest trace of cyanogen, hydrocyanic acid, or phosphuretted, sulphuretted, or carburetted hydrogen, except a very minute quantity of sulphuretted hydrogen in the air of a single vault, which contained but few coffins. The corroded parts of old leaden coffins were always found to be carburet of lead, with no trace of sulphate or sulphuret. Some of the coffins contained ammoniacal gas in large quantities, and others none at all; but, with this exception, the contained air was nearly alike in all, being composed of nitrogen, carbonic acid, common air, and animal matter in suspension. When ammonia was present, it overcame every other odour; when absent, the smell resembled that of very putrid moist cheese. The result was the same, whether the interment had been made a few weeks or a century and a half previously, whatever the cause of the disease, or the age at which it took place. Out of

all the coffins examined, but twenty of the leaden ones had been bulged by the pressure of the gases in the interior. This is only about one out of a thousand, and shows that the gases are formed very slowly. Mr. Lewis, from various inquiries, could not ascertain that a coffin had ever been known to burst suddenly from the pressure of the confined air. When one becomes bulged, it is customary for the sexton to make a small aperture in it, to which is applied a torch as an antidote to the noxious effect of the escaping gases. Several persons whom Mr. Lewis had consulted had heard of cases in which the gases caught fire, but, after searching inquiry, he could not find one who had ever seen them burn.

Mr. Lewis infers from the experiments made by him in vaults and catacombs, that the deleterious emanations from these depositories may continue for a hundred years after they are closed; they are not rendered noxious by poisonous gases generated during the process of decomposition, but by the animal matter itself, with which, if ventilation is not allowed, the air becomes saturated; that nitrogen and carbonic acid, holding animal matter in suspension, steadily but quietly make their way through the pores of lead coffins, and by the same means to the open air, so that, at the end of fifty or a hundred years, nothing remains but a few dry bones, though the coffins are still sound and unruptured.

Mr. Lewis, in conclusion, recommended that "interments in vaults and catacombs be no longer permitted, as they are but so many active volcanoes, constantly emitting poisonous effluvia; and that the use of leaden coffins should be entirely discontinued."—*Abridged from the Lancet*, 1851.

Mr. R. V. Tuson, in the *Philosophical Magazine* for April 1860, maintains that the substance obtained, as above, from leaden coffins is carbonate of lead—that it is anhydrous, contains but a small excess of oxide, and hence differs in composition from other carbonates of lead. It was found, during the search for the remains of John Hunter in 1859, in the vaults of the church of St. Martin's-in-the-Fields, that many leaden coffins had been converted, interiorly, all but a thin outer plate or foil, into this carbonate.

See also "How soon a Corpse decays," *Curiosities of Science*, First Series, p. 237.

VINOUS FERMENTATION.

In making wine, no yeast or other ferment is added to the must; but vinous fermentation ensues from the action of certain nitrogeniferous principles existing in the grape-juice, which confers upon them the properties of yeast. Hence it has been

asked why the juice of the grape does not ferment in the grape itself ; and how it is that ripe grapes, even when cut from the vine, not only exhibit no such tendency, but, as long as the skin is entire, shrivel up into *raisins*. This anomaly was hypothetically solved by assuming that the gluten or ferment was shut up in distinct vesicles, which, on mashing or pressing the fruit, were ruptured, and so became active. But Gay Lussac found that when thoroughly bruised grapes were carefully excluded from the air, or rather, when the grapes were crushed and pressed out of the presence of oxygen, no change ensued ; but that even a momentary exposure of the pulp to air or oxygen was sufficient to endue it with the power of fermentation.

It is curious to observe how admirably the exclusion of air is provided for by the natural texture of the grape, which does not allow its ingress, and yet admits of the egress or transpiration of aqueous vapour, as shown by the spontaneous desiccation of the berry.—*Brande's Lectures, abridged.*

These Lectures "on some of the Arts connected with Organic Chemistry," were delivered by Professor Brande, at the Royal Institution,* in the spring of 1852. At their close, Mr. Brande resigned his professorship, having been officially attached to the Institution for a period of forty years, or since 1812, when he succeeded to the chair vacated by Sir Humphry Davy. "Looking at the Royal Institution (said Mr. Brande), I revere it as my *alma mater*, where, as a schoolboy, I listened to the fruitful eloquence of Davy, and afterwards partook of his acquaintanceship and friendship ; where I acquired the patronage of Sir Joseph Banks ; where I was singled out by Wollaston as his successor in the secretaryship of the Royal Society ; where I came into frequent contact with the chiefs of science and of literature and art ; where Faraday became my pupil, my colleague, and my friend,—these, I assure you, are only a very few of the proud and pleasing reminiscences which accompany me from this place ; and they are unsullied and unalloyed. They have never been clouded, tainted, or embittered. I again, therefore, thank you for all your partiality and kindness ; and in gratitude to Providence, in whose merciful hands are all the issues of our lives, I respectfully beg you to accept my affectionate farewell."

VEGETABLE FERMENTATION.

Mitscherlich, of Berlin, believes fermentation to be brought about by the vital action of vegetable cells in a state of growth or development. Thus, the vegetable cells found in ferment-

* The Royal Institution has been worthily designated "the workshop of the Royal Society." The history of chemical science dates one of its principal epochs from the establishment of the laboratory of the Royal Institution. Here the researches of Davy and Faraday extended over half a century ; including the laws of electro-chemical decomposition, the decomposition of the fixed alkalies, the establishment of the nature of chlorine, the philosophy of flame—the condensibility of many gases, the science of magnetic electricity, the twofold magnetism of matter, and the magnetism of the gases. The mineralogical collection in the museum was commenced by Davy ; and in the library are preserved the great chemist's laboratory note-books.

ing beer are apparently of two kinds, and belong to the lowest forms of vegetable life. It is supposed that, through the agency of the vegetable cells, the sugar is decomposed, the carbonic-acid gas formed, and alcohol and water developed. The ultimate action, however, in the vegetable cell is due to catalysis, or to that modification of this force which Liebig calls molecular motion. For every germinating vegetable cell consists, first, of a quantity of matter—such as starch and sugar—without nitrogen; and secondly, a body containing nitrogen called *diastase*. This latter acts as a ferment during germination, and the results are nearly the same; the sugar, starch, &c. being decomposed, and one of the results the formation and disengagement of carbonic-acid gas.

COMBUSTIBILITY OF GASES.

The combustibility of gases is, to a certain extent, in direct proportion to the masses of heated matter required to inflame them. A red-hot wire one-fortieth of an inch in diameter will not ignite olefiant gas, but it will inflame hydrogen gas; and the same wire heated white-hot will inflame olefiant gas, but will not inflame the carburetted-hydrogen gas of the coal-mines, which, fortunately, is the least combustible of all the inflammable gases.—*Sir H. Davy*.

ABSORPTION OF GASES BY CHARCOAL.

When we had ascertained the fact of gases becoming fluid under the influence of cold or pressure, a curious property possessed by charcoal, that of absorbing gases to the extent of many times its volume,—ten, twenty, or even, as in the case of ammoniacal gas or muriatic-acid gas, eighty or ninety fold,—which had been long known, no longer remained a mystery. Some gases are absorbed and condensed within the pores of the charcoal into a space several hundred times smaller than they before occupied; and there is now no doubt they there become fluid or assume a solid state. As in a thousand other instances, chemical action here supplants mechanical forces. *Adhesion*, or heterogeneous attraction, as it is termed, acquired by this discovery a more extended meaning. It had never been before thought of as a cause of change of state in matter; but it is now evident that the adhesion of a gas to the surface of a solid body is a process opposite to that of solution.—*Liebig*.

WHAT IS DONE WITH THE GASES?

One species, or rather a variable mixture of two or three, composed of carbon and hydrogen, is made in the outskirts of

nearly every town nowadays in enormous quantities, and then sent away from a huge trough or jar, or from a heart, to circulate through a system of metallic arteries for the purpose of lighting streets and houses. Hoffman's spirit of charcoal, the fixed air of Black, the carbonic acid of the present nomenclature, is studiously crushed into bottles of soda-water by stout machinery, to be quaffed by the luxurious and the ailing before it has time to fly away. Our cottons and linens are bleached by chlorine. Great balloons are filled with the phlogisticated air or hydrogen of Cavendish, the lightest of corporeal bodies, to carry men of science and fools with singular impartiality. Oxygen and hydrogen are separated from chemical union with one another in water, suffered to remain mechanically mingled, and then made to unite by combustion at the nozzle of the oxyhydrogen blowpipe, so as to produce beautiful and useful results. The arsenic that may lurk about the putrid remains of a dead and buried man is transformed by an easy process into arseniuretted-hydrogen gas, so as by its decomposition to bring the metal that laid him low before the eye of a jury. The spirit of hartshorn is now understood to be but a compound of nitrogen and hydrogen, called ammonia, absorbed by and probably in combination with water ; while the old spirit of salts, or muriatic acid, is just an aqueous solution of hydrochloric gas. The nitrogen is seduced into something like an unwilling chemical union with the oxygen of the atmosphere, by a device borrowed from nature, so as to yield the nitrate of lime, the nitrate of potassa or saltpetre, the nitrate of soda, and (by a secondary process) the nitric acid or nitrate of water itself, that invaluable oxidant and solvent of the metallurgist and the chemist.* In fact, there is no end to the application of this pneumatic chemistry, which took its rise from the mind of Joseph Black, who lived as fine a life of science as was ever lived, and died with a cup of milk unspilt in his hand.—*North British Review*, No. 35, abridged.

* Nitric acid will entirely dissolve bone and flesh, both disappearing without any smell. Professor Horsford, of the United States, considers that it would take rather more nitric acid than the weight of the whole flesh and bone to dissolve a human body.

Chemistry of Metals.

TRANSPARENCY OF METALS.

OPACITY is an almost universal characteristic of metals, as we see them ; but gold has been beaten into leaves so fine as to become partially transparent,—not in consequence of any cracks, holes, or fissures, but by the shining of light through its substance. These leaves are 1-200,000th of an inch in thickness. The light transmitted is green, although the incident ray is white ; thus negating the supposition of a mere passage through orifices in the gold, and proving the metal to possess a true refractive power, unequal for different colours of light, as is the case with most transparent media. Silver-leaf only 1-100,000th of an inch in thickness is perfectly opaque.

The above phenomenon of gold renders the supposition probable that other metals might also become transparent, provided they were sufficiently malleable to be beaten out into leaves of the necessary fineness ; and thus we are obliged to relinquish the idea of opacity as being necessarily a quality of metallic bodies.—*Faraday*.

RUST A PROTECTOR.

All the common metals, except tin (says Faraday), rust ; they become duller and duller up to a certain degree, lose gradually their lustre, and then the process goes no farther. Instead of the rusting being a destroyer of the metal, it is a preserver ; for even in the case of iron, which rusts quickly as compared with other metals, if it be dipped into tin, it comes out coated with it, and is preserved beautifully. If iron be exposed for a couple of hours to the action of water, the iron becomes quite corroded ; but when tinned, the iron is protected, and the tin itself is not affected. How is it that this metal can protect itself, and the iron that is under it ? It is simply owing to the substance formed on the surface by the attraction of oxygen, which is so adherent to the metal beneath. It gives a protection which no varnish nor any kind of application can afford. Take a copper or a tin plate ; they are both protected in their metallic state by a thin coat formed in the first instance of oxide. It is only because this coat is so

exceedingly compact, close, and adherent, that it passes for nothing—a mere film of tarnish. You think you see or touch a piece of tin; you cannot detect the film except by close examination. We know it is there; but it is only by optical phenomena that we can measure its thickness. It seems clear and beautiful, but if you rub it off, you give the metal beneath a new character; the lustre, however, passes off the first moment up to a certain point. The body formed by the combination of oxygen with iron is different. The oxide does not adhere to the metal beneath; it forms upon it little spots, or porous tumuli. It is not an investing varnish; but the process goes on through the pores of the rust, especially if the metal be placed in a damp atmosphere. This is the reason why we find a difference between copper, iron, tin, and lead, when used for roofs, or other external purposes. The iron alone is eaten into and destroyed by this want of adhesion in its rust to the surface of the metal.

It is curious to observe, in some cases, how tin, as metal having a slight attraction for oxygen, protects other metals from oxidation. In Canada, tin-plate is used for the roofs of houses: you are dazzled by the lustre of the sun acting upon the roofs; and there, although it is exposed to the atmosphere year after year, it does not decay, because the superficial coat of oxide protects the tin and iron beneath.

ANTIMONY.

We have already adverted to the high appreciation of this metal by the Alchemists (see page 12). Here is a beautiful experiment:

On electrolysing a solution of terchloride of antimony (one part of tartar-emetic in four parts of ordinary chloride of antimony) by a small battery of two elements, metallic antimony forming the positive, and metallic copper the negative pole, crusts of antimony are obtained, which possess the remarkable property of exploding and catching fire when scratched or broken.—*Gore; Proceedings of the Royal Society*, vol. ix.

Besides its application to medicine, antimony is of great importance in the arts, inasmuch as it forms with lead *type-metal*. This alloy expands at the moment of solidifying, and takes an exceedingly sharp impression in the mould. It is remarkable that both its constituents shrink under similar circumstances, and make very bad castings.

Tersulphide of antimony is employed in the Bengal or blue signal-light used at sea, as follows: dry nitrate of potassa, six parts; sulphur, two; tersulphide of antimony, one.

To show how little the early chemists understood of the distinction between organic and inorganic or mineral sub-

stances, it is recorded that they classified chloride of antimony (butter of antimony) next to the butter of the cow!

ARSENIC.

Arsenic is first mentioned in the works of Dioscorides, but is there thought to have been the well-known paint orpiment. Though long known, it was first examined with tolerable precision by Brandt, in 1733. It is very frequently met with in nature, sometimes in its pure metallic state of steel-gray colour, and considerable brilliancy, which it soon loses on exposure to the air, and becomes black on the surface; the artificially obtained metal not only suffers these changes, but falls to powder by the action of the air, and in this state is known on the Continent as *fly-powder*. When kept under water, arsenic undergoes no change; if heated to 356° Fahr. it is volatilised without previous fusion; the vapour has the odour of garlic, which is relied upon as a proof of its presence. This substance combines with metals in the same manner as sulphur and phosphorus, which it resembles, especially the latter. With oxygen it unites, giving rise to arsenious and arsenic acids.

Arsenic in the oxidised state is found in minute quantities in many mineral waters. It is mostly derived from roasting natural arsenides of iron, nickel, and cobalt; the volatile products being condensed in a chimney divided into chambers.

Of the various Poisonings by Arsenic we shall speak in a future page.

SILVER.

Silver is found principally in the mines of the Harz mountains in Germany, Königsberg in Norway, and the Andes in North and South America. It is mostly extracted from poor ores, not by smelting, but by amalgamation, as silver and many other metals are easily soluble in metallic mercury. Pure silver is probably the best conductor of heat and electricity known. In hardness it lies between gold and copper. Silver is unalterable by air and moisture; it refuses to oxidise at any temperature, but possesses the extraordinary faculty of absorbing many times its volume of oxygen when heated strongly in an atmosphere of that gas, or in common air. The oxygen is again disengaged in the appearance often remarked on the surface of masses or buttons of pure silver. The addition of 2 per cent of copper is sufficient to prevent this absorption of oxygen. Silver oxidises when heated with fusible siliceous matter, as glass, which it stains yellow or orange, from the formation of a silicate. The tarnishing of silver exposed to

the air is due to sulphuretted hydrogen, the metal having a strong attraction for sulphur.

The lunar caustic of the surgeon is nitrate of silver, which has been melted, and poured into a cylindrical mould. The salt blackens when exposed to light, more particularly if organic matters of any kind be present; and it communicates a dark stain to the hair, and is employed in "indelible" ink for marking linen. The black stain is thought to be metallic silver; it may possibly be suboxide.

Berthollet's *Fulminating Silver* was precipitated oxide of silver digested in ammonia: it explodes while moist, when rubbed with a hard body; but when dry, the touch of a feather is sufficient. A similar compound containing oxide of gold exists.

It is easy to understand the reason why these bodies are subject to such violent and sudden decomposition by the slightest cause, on the supposition that they contain an oxide of an easily reducible metal and ammonia: the attraction between the two constituents of the substances is very feeble, while that between the oxygen of the one and the hydrogen of the other is very powerful. The explosion is caused by the sudden evolution of nitrogen gas and vapour of water, the metal being set free.—*Fownes's Manual*.

Silver is admirable for culinary and other economical uses, not being attacked in the slightest degree by any of the substances used for food. It is necessary, however, in these cases to diminish the softness of the metal by a small addition of copper. The standard silver of England contains 222 parts of silver and eighteen parts copper.

In the time of William the Conqueror, the English pound was a pound weight of silver, coined into twenty shillings; now a pound is worth less than four ounces of silver, and the pound is coined into sixty-six shillings. Here is the scale of reductions taken from Lord Liverpool's *Treatise on Coin*:

	s.	d.
28th Edward I., a pound-weight of silver was coined into	20	3
18th Edward III.	22	0
20th Edward III.	22	6
27th Edward III.	25	0
13th Henry IV.	30	0
4th Edward IV.	37	6
18th Henry VIII.	45	0
2d Elizabeth	60	0
43d Elizabeth	60	0
56th George III.	66	0

Jonathan Duncan, B.A., on the Currency, 1857.

The new art of Photography is founded on a knowledge of the properties of four chemical compounds of silver, viz. on the change produced by the influence of light on chloride and iodide of silver; on the reconversion of the altered silver compound into metallic silver by means of pyrogallie acid or some other reducing agent; on the solubility of silver compounds in

water containing sea-salt or hyposulphite of soda ; and finally, on the solubility of collodion in alcohol.

FINE DIFFUSION OF GOLD.

Professor Faraday supposes that if a leaf of gold, which is only $\frac{1}{100000}$ of an inch thick, and weighs about 0.2 of a grain, yet covers a superficies of nearly ten square inches, were diffused through a column of solution having that base, and 2.7 inches in height, it would give a ruby fluid equal in depth of tint to a good red rose ; the volume of gold present being about the one five hundred thousandth part of the volume of the fluid.

HARDNESS OF METALS.

Messrs. Calvert and Johnson have made a series of experiments with pretty large masses of metal to test their comparative hardness ; and the following is a most useful table which has been prepared, embracing the results of their investigations :—

Names of Metals.	Hardness.
Cast Iron	1.000
Steel	—
Wrought Iron . . . . .	.948
Platinum . . . . .	.875
Pure Copper . . . . .	.801
Aluminium . . . . .	.271
Silver . . . . .	.208
Zinc . . . . .	.183
Gold . . . . .	.167
Cadmium . . . . .	.108
Bismuth . . . . .	.52
Tin . . . . .	.27
Lead . . . . .	.10

This table exhibits the remarkable fact that cast iron is harder than all the other metals ; it was found to be harder than any alloy.

It is well known to chemists that cast iron, and one or two other metals, in the act of solidifying enlarge, so as to fill out sharply the minute parts of the mould, which is, indeed, the property on which their great use chiefly depends.

GOLD TESTS.

Mr. Tennant, the practical mineralogist, states the specific gravity of gold, tried by four different tests, to be, 15, 15.7, 16.5, 17 ; so that, as a mean, the specific gravity of gold is sixteen times greater than water ; while that of copper pyrites is 4.5 ; iron pyrites, 4.3 ; mica, 3. The blowpipe is a most useful and simple instrument in these operations : it

can be used with a penny candle and a halfpenny-worth of charcoal ; so that for eightpence or tenpence a primitive furnace can be purchased. Gold may be cut with a knife like lead, and bent and beat out in thin leaves. Iron pyrites cannot be cut, or even scratched with a knife ; copper pyrites can ; and both are brittle. Mica is foliated and elastic. When the blowpipe is applied to gold, it retains its colour ; while copper and iron pyrites lose theirs, and the latter become magnetic. Gold is also not acted upon by nitric, muriatic, or sulphuric acid singly : brass filings are readily acted upon by nitric acid. A mixture of nitric and muriatic acids dissolves gold, and is therefore named *Aqua Regia*, gold being the king of metals.

SCIENTIFIC GOLD-SMELTING.

It is not the precious character of a metal in a mine that renders it important, but its relative amount, making the difference between profit and loss in obtaining it. Mines which have been abandoned for centuries on account of their poverty, though known to be auriferous, have often been rendered profitable in working by an application of science. The gold-mines of Reichenstein in Silesia had been abandoned for five centuries, when the process of Professor Plattner was adopted. The ores of the mines are arsenical pyrites, containing about 200 grains of gold in the ton. These are roasted in a reverberatory furnace, surmounted by a large condensing chamber, on which the arsenic is deposited as it rises in fumes. Oxide of iron, a certain quantity of arsenic, and the gold in the ore, remain beneath. These are placed in a vessel, so that a current of chlorine gas is transmitted through them. The gold and iron are attacked, are separated from the residue by solution in water, and the gold is precipitated by sulphuretted hydrogen. The importance of this process is evident ; and it is but justice to Dr. Percy to state that in 1848 he advocated the employment of chlorine for a similar purpose.

In Hungary, from a depth of 200 fathoms, the gold matrix is raised, and so skilfully manipulated as to work at a profit, although only producing one-tenth of an ounce of gold from a ton of the matrix.

METALLIC MANGANESE.

The great hardness of this metal fits it for mechanical use : it turns the edge of the best-tempered files, and, set at a sharp angle, it can be advantageously substituted for the diamond in cutting glass, and even in the polishing of steel and other metals. It is so susceptible of polish as to appear applicable for the purposes of optical instruments—for instance, the mir-

rors of telescopes; and plates of it have been kept for two months in the atmosphere of a laboratory, charged throughout with moisture and other vapours, without the polish having suffered. Although it cannot be forged, it can be rolled into shapes. Its alloys are capable of yielding useful substances. It is an established fact, that all steel contains small portions of manganese. It has long been considered indispensable to add substances which contain this metal to the powder used for cementation in making steel. The valuable variety of steel known as *Wootz* perhaps owes its properties to the *addition* of manganese.

DISCOVERY OF CHLORINE.

At the close of the last century, the Swedish chemist Scheele made a series of experiments on the black oxide of manganese. To some this might have seemed an unprofitable waste of time; but what was the result? Chlorine was discovered, a substance of the greatest importance in the arts. Berthollet, finding that this gas changed the colour of the corks of the bottles in which it was confined, suggested its employment as a bleaching agent. This led to a total revolution in the art of bleaching, shortening the process from several months to a few hours.

By far the most eligible method of employing the bleaching agencies of chlorine consists in combining it with lime ("bleaching powder"), as follows: Gaseous chlorine, being liberated from a mixture of salt, sulphuric acid, and black oxide of manganese, is caused to pass over and among large bulks of slacked lime, which, being continually moved about by rakes, the full absorption of chlorine is obtained. Chlorine is, however, devoid of bleaching power except it be in the presence of water. The *rationale* of this requires to be explained. Chlorine, by action on water, decomposes the latter, giving rise to the formation of hydrochloric acid, and the liberation of oxygen. Most probably the ultimate bleaching effect is due to the *oxygen* thus liberated.—*Brandé's Lectures*, by Scoffern.

RESTORATION OF ANCIENT BRONZES.

M. Chevreul selected, from among certain ancient bronze statuettes brought from Egypt, a small completely oxidated figure of Anubis, and placing it in a porcelain tube, he filled the tube with hydrogen gas, and raised it to a dull red heat. Presently, water of a green colour was seen to condense in the bell-glass; and after letting the apparatus cool, "I took out the statuette," says Chevreul, "completely revived. I placed it before the French Academy, together with the water and chlorhydric acid, which represented the oxygen and chlorine of Egypt transformed at Paris by hydrogen into water and acid."

THE ANCIENT EGYPTIANS' WORKING METALS.

The skill of the Egyptians in metallurgy was very great : we have ample proof of the working of metals at the earliest times of which any monuments remain ; nor is it too much to say that some of the secrets they possessed, particularly in the manufacture of bronze, are still imperfectly known to us.

In connection with this art, the paintings notice the forceps, the blowpipe, and the bellows, which last even appear to show an acquaintance with the principle of the valve ; and though they give very few of the inventions of Egypt, they prove the early use of the syphons, and many efficient tools of different crafts. The syringe was also known ; and one instrument occurs, even on the monuments of the fourth dynasty, which has the appearance of a hand-pump. And if many of their arts, as well as their skill in mensuration, geometry, arithmetic, astronomy, and various branches of science, are unnoticed, we are not surprised at the omission of subjects so little suited to sculpture, or the embellishment of a tomb.

Surgical instruments have been found ; and in the tombs other instruments, chiefly bronze ; among which are small bells, but it is uncertain to what period they belong, or when bells were first invented. There are likewise knives of various forms ; one of them, now in the Louvre collection, is 12 inches long. Bronze needles were not uncommon ; and a pair of bronze tongs found at Thebes, and now in the British Museum, are remarkable for their finish, and for the very Egyptian caprice of making their two ends in the form of fish.

Though gold-beating in its modern advantageous state is an improvement of the seventeenth and eighteenth centuries, the Egyptians overlaid wood and other materials with leaf of great fineness at a very remote age ; and beating, damascening, engraving, casting, inlaying, wire-drawing, and other processes, were adopted by them more than 3000 years ago. It is not, therefore, surprising that Homer should mention the horns of an ox overlaid with gold, as well as other arts long known in Egypt. But the covering of gold was generally of considerable thickness compared to what we use at the present day.

Gold was the precious metal *par excellence*, and is shown to have been used in Egypt at an earlier time than silver, this last being called "white gold," or "*noub-hat*," whence *hat*, "white," alone came to signify "silver." The Egyptians had no coined money : their gold and silver was in rings, similar to those used in the present day at Sennaar ; and, like the iron rings of the ancient Britons mentioned by Cæsar, when purchases were made, they were tried in the scales to ascertain if the "money" was "in full weight."

The use of other metals, as tin and zinc (mostly for bronze and brass), as well as iron and steel, is either directly proved by discoveries in the tombs, or inferred from the monuments: and the manufacture of bronze is shown to have dated at least as early as the fifth dynasty, more than 4000 years before our era. The bronze of Egypt varied in its quality according to the alloys it contained, some having more or less tin, some being mixed with silver or other metals; but that for ordinary purposes contained 80 or 90 of copper to 20 or 10 of tin, like most bronze of Roman times. The fine quality of Egyptian metal mirrors and other ornamental objects is well known.

THE INVENTOR OF AMALGAMATION.

In the year 1640, there was written a work on metallurgy, and the use of quicksilver in refining gold and silver, by Alonzo Barbara, a minister of the church of St. Bernard at Potosi. He discovered the process of amalgamation by mere accident; for being desirous of fixing quicksilver, he mixed it with finely-powdered silver-ore, and soon found that the mercury had attracted every part of silver to itself, which presented him with the idea of refining metals by means of mercury. This experiment he made in 1600; but he was probably unacquainted at the time with the existence of smelting-works in America, and does not appear desirous of claiming the invention of amalgamation as practised in that country. The book, though published at that late period of the art, and notwithstanding there were many superior treatises on the same subject already published in German, was considered of such importance by the Spaniards, as containing all their metallurgic secrets, that they endeavoured to suppress it; but a portion of it was translated into English in 1674.

The late Mr. Children, F.R.S., discovered a method for extracting silver from its ore without amalgamation, and derived considerable profit by selling the right to use it to several South American mining companies, in the year 1824.

THE MANUFACTURE OF IRON.

Of all the metals, Iron is the most widely diffused, the most abundant, and the most useful. Hence the processes of its application are the most numerous; and their history carries us back to the remotest ages. It has been shown, by reference to the four books of the Mosaic law, that Iron was known and used in the earliest ages of the world. In Deuteronomy it is cited as the essential and last fruit of the promised land. From various passages in Hesiod, Homer, and Æschylus, it is rendered probable that the ancient Greeks, though acquainted with both

iron and bronze, used the latter in the construction of their warlike weapons till the period of the Heroic ages; but that after that time bronze was superseded by iron obtained from the Chalybes; and from passages from the writings of Polybius, Pliny, and Diodorus, the conclusion is drawn that even in the earliest times the Romans used weapons of iron which they obtained principally from Spain. Mr. Arthur Aikin mentions as a curious fact, that cutting and even surgeons' instruments were found in the excavations at Herculaneum and Pompeii made of *bronze*, though some were also found of iron; from which it is to be concluded, that at this period (about the year 59) the great superiority of iron over every other kind of metal in the manufacture of cutlery was only partially acknowledged.

Sir Gardner Wilkinson informs us that Iron was known in Egypt at a very remote period; and the butchers sharpening their knives on a bar, which, from its blue colour, was evidently steel, is represented on monuments of the fourth dynasty, as well as on those of later time. The case-hardening of iron, by plunging it red-hot into water, is even mentioned by Homer; and the more we inquire into and become acquainted with the customs of people in the early ages of the world, the more we are convinced that iron supplied their simplest wants much in the same way at all times, and that many secrets were known which we blindly suppose to be of late date. If Tubal Cain was, ages before the time of Moses, "an instructor of every artificer in brass and *iron*," the discovery of these will not date at a very recent period. Nor is it sufficient to establish the fact of an acquaintance with the use of iron: it is evident that its properties as steel were not unknown; and those who deny a nearer approach to it than case-hardening will find it difficult to reconcile the mention of "a bow of steel" (Ps. xviii. 34), and other evidence of its use, with the mere hardening of the external surface of iron.

Dr. Livingstone, in his recent researches in South Africa, found on the river Lucalla the strong massive ruins of an iron-foundry, erected in the year 1768, and by the order of the famous Marquis of Pombal. The whole of the buildings were constructed of stone, cemented with oil and lime. The dam for water-power was made of the same materials, and 27 feet high. This had been broken through by a flood, and solid blocks many yards in length were carried down the stream, affording an instructive example of the transporting power of water. There was nothing in the appearance of the place to indicate unhealthiness; but eight Spanish and Swedish workmen being brought hither for the purpose of instructing the natives in the art of smelting iron, soon fell victims to disease and "irregularities." The effort of the Marquis to improve the mode of manufacturing iron was thus rendered abortive. Labour and subsistence are, however, so very cheap, that almost any amount of work can be executed at a cost that renders expensive establishments unnecessary. A party of native miners and smiths is still

kept in the employment of the Government, who, working the rich, black, magnetic iron-ore, produce for the authorities from 480 to 500 bars of good malleable iron every month. They are supported by the appropriation of a few thousands of a small fresh-water fish, called "cacush," a portion of the tax levied upon the fishermen of the Coanza.

—*Dr. Livingstone's Missionary Travels.*

The art of smelting iron was known in England during the time of the Roman occupation; and in many ancient beds of cinders, the refuse of iron-works, Roman coins have been found.*

The working of steel was also practised in Britain before the Norman conquest; and we are told that not only was the army of Harold well supplied with weapons and defensive armour of steel, but that every officer of rank maintained a smith, who constantly attended his master to the wars, and took charge of his arms and armour, to keep them in proper repair.

The principal ancient seats of the iron manufacture in this country appear to have been in Sussex, and the Forest of Dean, or Arden, as it was then called. It is known that iron-works existed in that part of Gloucestershire in 1238, because there exists among the patent rolls of Henry III. of that date one entitled "De Forgeis levandis in foresta de Dean." Remains of ancient iron-furnaces have also been found in Lancashire, Staffordshire, and Yorkshire.

In South Wales, a charcoal furnace and forge were commenced at Pontypool in the 16th century (about 1505), so that this is one of the earliest seats of the iron-trade; but there is reason to believe that the Romans worked iron-ore in these hills, as they undoubtedly did in Dean Forest, ancient heaps of slag being occasionally struck upon. The early furnaces consumed so much timber for fuel, that in the reign of Elizabeth acts were passed prohibiting the erection of iron-works, except in districts specified. Many years elapsed before coal could be successfully applied to the smelting of iron; but in 1740, after nearly a century and a half had been wasted, this great result was obtained at the Coalbrooke iron-works in Shropshire. In that year Monmouthshire only contained two furnaces, the make of which was 900 tons annually; and so slowly did the trade progress, that in 1788 only one more furnace had been put up; but the aggregate make of the county had increased to 2100 tons, owing to the use of the steam-engine. The Nantyglo works, now almost the greatest in the world, were commenced in 1795. The iron-works in the Monmouthshire hills now extend about twenty miles; and mineral property here has risen from 5s. an acre surface-rent to 1500*l.*, or more,

* Iron is described by Cæsar as being so rare in Britain, that pieces of it were employed as a medium of exchange; but a century later it had become exceedingly common, since in Strabo's time it was an article of exportation.

underground. In the vale of Taff, before the 17th century, rude attempts were made to smelt iron-ore; the bellows was worked by a water-wheel, and charcoal used instead of coke. Merthyr, the "iron capital" of the district, is scarcely a century old. Here, at the Cyfarthfa works, are employed upwards of 4000 men, including colliers; and the strata of coal lie parallel with veins of argillaceous iron-ore. This is the great seat of the bar-iron manufacture for railways.

The chief iron-works of Sussex were in the Wealden strata, whence the iron-ore was extracted from the argillaceous beds, and was smelted with charcoal made from the abundance of wood. At Buxted, near Lindfield, iron ordnance were made three centuries since.* Up to 1720, Sussex was the principal seat of the iron manufacture in England: the last furnace, at Ashburnham, was blown out in 1827. Kent was alike noted for its iron; and the last great work of its furnaces was the noble balustrades and gates which surround St. Paul's Cathedral, London: they were cast at Gloucester furnace, Lamberhurst, and cost upwards of 11,202*l*. "In the middle ages, and down even to a late date, while Dudley and Wolverhampton were obscure names, the forges of Kent and Sussex were all a-glow with smelting and hammering the iron which the soil still yields, although it is not worth the while of any one to work it. The discovery of the coal-fields of Wales and Staffordshire gave the Kent and Sussex furnaces their death-blow, leaving the country dotted with forge and furnace farms, and deep holes, now filled with tangled underwood, from which the ore was brought." (*Saturday Review*, No. 182.) Kent and Sussex have no coal, and the iron manufacture left these counties when smelting with coal or coke began to supersede smelting with charcoal.

Iron was also worked in Surrey. John Evelyn, in a letter to John Aubrey, dated February 8, 1675, states, that on the stream which winds through the valley of Wotton "were set up the first brass mills, for casting, hammering into plates, and cutting and drawing into wire, that were in England; also a fulling mill, and a mill for *hammering iron*, all of which are now demolished. Such a variety of mills on so narrow a brook, and so little a compass, at that time was not to be met with in any other part of England." The last of these mills gave its name to a small street or hamlet in the parish of Abinger, which to this day is called *the Hammer*.

* Iron ordnance were first cast in 1543, at Buxted in Sussex, by Ralph Hogge, assisted by Peter Bawde, a Frenchman, and his covenanted servant John Johnson; and the memory of whose works, of which two specimens are still existing in the Tower of London, is preserved in

"Master Hogge, and his man John,

They did cast the first can-non."

—*W. D. Cooper, F.S.A., Archæologia*, vol. xxxvii. p. 483.

The principal operations of the iron manufacture have been thus briefly described by Mr. Noad : There are upwards of forty different ores of iron, the metal occurring in all rocks. The amount of carbonate of iron in the coal-measure iron-stones varies from 50 to 80 per cent. There are two distinct qualities, pig-iron and malleable or bar-iron, the second being the result of an extension of the processes necessary for the production of the first kind, pig-iron. The first process is the *Blasting*. The blast-furnace is composed of stone or brick, within which is a casing of masonry about fourteen inches thick ; next comes a space of about six inches filled with river sand, compactly rammed in, which, being a bad conductor of heat, tends to preserve the casing of masonry ; lastly, is a coating of best fire-brick about fourteen inches in thickness. The furnace when in full work contains upwards of one hundred tons of materials, to supply the requisite heat for which a powerful and constant blast of air is sent in at three or four different sides through tubes surrounded with a stream of cold water, and which tubes are called "*Tuyeres*." Some of the large Welsh furnaces consume upwards of 20,000 gallons of air per minute, a quantity exceeding in weight the totals of all the solid materials used in smelting. The blast enters the furnace under a pressure of from two to three pounds and a half to the square inch, the air being heated to about 600° before it enters the furnace, by which an effective increase of about one-eighth, or of 360° Fahr., is obtained.

This improvement has in many cases enabled manufacturers to increase their weekly production of iron 50 per cent, and to produce a better sort of cast iron from inferior materials. It has effected a great saving of fuel ; and it has enabled the Scotch iron-masters to smelt alone and with coal the *black-band* iron-stone, discovered by Mr. Mushet in 1801. The colour, consistence, and general appearance of the cinders, or slag, indicate the working of the furnace. They are received from the furnace in large iron boxes, whence, as soon as they have solidified, they are removed on railways, to be used for the construction of roads, rough walls, &c. The iron from the blast-furnace is usually "*tapped*" twice in twenty-four hours ; the liquid metal is either received into moulds, where it assumes the form of semi-cylindrical bars, technically called "*pigs*," or it is run into wider channels, from which, after being broken up, it is removed directly to the "*refinery*." The cinders alluded to above are not the cinders of the blast-furnace, but forge cinders, that separate from the cast iron during the processes of refining, puddling, and balling, by which the cast iron is converted into wrought iron. These cinders are very rich in iron, and are calcined to rid them of sulphur, which would make the metal "*hot short*," so that it could not be worked

under the hammer. The forge cinders also contain phosphorus, which cannot be separated, and makes the iron "cold short," so that it breaks on attempting to bend it. Lastly, the gases from the furnace are economically applied: of the heat produced by the combustion of the fuel in a coal-fed blast-furnace, only 18·5 per cent was originally realised in carrying out the processes of the furnace, the remainder 81·5 per cent being lost. This loss is no longer permitted. The gases are now collected at the mouth of the furnaces, and conveyed by large pipes underneath the boilers of the engines and round the hot-air stoves. The principle has been carried out in great perfection at Cwm Celyn: the pipes are six feet in diameter, and are lined with fire-brick; and the gases from *two* furnaces only more than suffice for the supply of seven boilers, and for the hot blast for both furnaces, at a saving of full 10,000 tons of coal a year.

Foremost among the great improvers of the iron manufacture ranks Henry Cort, who, in 1783-4, introduced the flame of pit-coal in the puddling furnace, and the passing of wrought iron through grooved rollers instead of forging under the hammer; yet the inventor of these valuable improvements, and his descendants, have been deprived of their just reward.

Although in England the use of iron as a building material is comparatively modern, M. Gutzlaff has proved that the art of constructing buildings of cast iron has been known for centuries in China. He discovered there a pagoda entirely built of cast iron, and covered with bas-reliefs and inscriptions, which in their forms, characters, and dates, show that they are as old as the dynasty of Tang, which was upon the throne from the fifth to the tenth century of the Christian era. The pagoda has seven stories, each containing curious historical pictures; it is strikingly elegant in form, and in this respect surpasses every thing hitherto seen by M. Gutzlaff in China.

Mr. Rennie first largely employed iron as a building material, as *voussoirs* (wedges), in the Southwark Bridge. Vast roofs are now constructed of iron; and lighthouses, churches, factories, and storehouses, are manufactured in England, then taken to pieces, to be reërected in all parts of the world. The strength of this metal in building is enormous, since iron with 1-40th part of the substance of stone will give equal strength of support.

THE MANUFACTURE OF STEEL.

The existing and generally-received theory of the formation and the alleged actual composition of Steel is, that it is produced by the addition to pure iron of some apparently insignificant proportion of carbon. This simple combination is, and ever

has been alleged to be, the sole cause of the *conversion* of iron into Steel. This magical effect, which is a kind of chemical anomaly, has been disputed by Mr. C. Binks, who, from a practical investigation of considerable length and detail, adduces evidence proving :

That the substances whose application to pure iron convert it into Steel all contain nitrogen and carbon, or nitrogen has access to the iron during the operation.

That carbon alone, added or applied to pure iron, does not convert it into Steel.

That nitrogen alone, so added or applied, does not produce Steel ; but that it is essential that both nitrogen and carbon should be present, and that no case can be adduced of conversion in which both these elements are not present and in contact with the iron.

That nitrogen as well as carbon exists substantially in Steel after its conversion ; and such presence is the real cause of the distinctively physical properties of steel and of iron, in which latter those elements do not exist.

That presumptively, but not demonstratively, the form of combination is that of a triple alloy of iron, carbon, and nitrogen ; but it remains to be determined as to the relative proportion of elements when their union gives pure Steel.

Mr. Binks then proceeds to show there to be nothing in the chemical history of nitrogen that is incompatible with its substantial existence in Steel.

In the presence of our atmosphere, with its affluence in nitrogen, why should we ever ascribe to that element some merely negative attributes, or properties serving only to control or modify the more vivid action of some other element ? An element existing every where, touching every thing, penetrating, permeating, and by diffusion intermingling itself with, every gaseous body it comes in contact with, might be supposed, *a priori*, to exercise other functions (and many) besides the merely negative ones usually assigned to it. And, among speculations that naturally arise out of these questions, is it quite impossible that the play of colours peculiar to heated steel—the assumption, for example, of the pure blue and the purple—may not in reality be due to some phase of development of some of the forms of ferrocyanide of iron ?

We possess further evidence of the use of nitrogen from another and unexpected quarter. It is on record, as a practice of the Indian *Wootz*-Steel maker, that along with his iron or imperfect Steel, in his melting-crucible, he places, as his carbon-giving material, the wood of the *Cassia auriculata*, and covers the whole with the leaves of the *Convolvulus laurifolia*, both vegetable productions rich in azotised matters. These, placed in his closest crucible, will give an azotised carbon in contact with the metal. And what may have been the origin of this far-back practice of the East—this to us apparently the empirical handicraft of some Indian artificer ? Has it originally been the fruition of some mere accident, or of some induction or deduction ? or is it a relic of some state of civilisation and of science superior to those of the West ? The Sheffield artisan seeks, even up to the present day, that which the Indian artificer had found out ages ago.

Mr. Faraday has made a series of investigations with the object of ascertaining what metals could be advantageously employed as alloys of Steel, in order to improve its hardness and temper. Among the important practical results of this research, we may notice the fact that the addition of a small quantity of silver (1 part in 500) produces a steel decidedly superior in quality to the best previously manufactured.

STEEL PRODUCED BY GALVANIC ACTION IN THE EARTH.

The late Mr. Weiss, to whose inventions modern surgery is under considerable obligations, remarked that Steel seemed to be much improved when it had become rusty in the earth, and provided the rust was not factitiously produced by the application of acids. He accordingly buried some razor-blades for nearly three years, and the result fully corresponded to his expectation. The blades were coated with rust, which had the appearance of having exuded from within, but were not eroded, and the quality of the steel was decidedly improved. Analogy led to the conclusion that the same might hold good with respect to iron under similar circumstances: so, with perfect confidence in the soundness of his views, he purchased, as soon as opportunity offered, all the iron, amounting to fifteen tons, with which the piles of old London Bridge had been shod. Each shoe consisted of a small inverted pyramid, with four straps rising from the four sides of its base, which embraced and were nailed to the pile; the total length, from the point which entered the ground to the end of the strap, being about sixteen inches, and the weight about eight pounds. The pyramidal extremities of the shoes were not found to be much corroded, nor, indeed, were the straps; but the latter had become extremely and beautifully sonorous. When manufactured, the solid points in question were convertible only into very inferior Steel; the same held good with respect to such bolts and other parts of the iron-work as were subjected to the experiment, *except the straps*; these straps, in addition to the sonorousness, possessed a degree of toughness quite unapproached by common iron; they were, in fact, imperfect carburets, and produced steel of a quality infinitely superior to any which Mr. Weiss had ever met with; insomuch that while it was in general request among the workmen for tools, they demanded higher wages for working it. The straps were consequently separated from the solid points, which last were sold as old iron. The exterior difference between the parts of the same shoe led at first to the supposition that they were composed of two sorts of iron; but, besides the utter improbability of this, the contrary was proved by an examination, which led to the inference that the extremities of the piles having been charred,

the straps of iron, closely wedged between them and the stratum in which they were imbedded, must have been subjected to a galvanic action, which, in the course of upwards of six hundred years,* gradually produced the effects recorded.

DISCOVERY OF SCARLET DYE.

A scarlet colour resulting from the treatment of a decoction of cochineal with a chloride of tin (and tartar), is a very celebrated dye, and has a curious history. It appears that the Dutch chemist Drebbel, resident at Alkmaar, had prepared some decoctions of cochineal for filling a thermometer-tube. The preparation was effected in a tin vessel; and into this some *aqua regia* (nitro-muriatic acid) having been spilled by accident, a rich scarlet colour was observed. Thus, by mere chance, was the discovery made that oxide of tin in solution yielded, by combination with the colouring matter of cochineal, a scarlet dye. Drebbel communicated his discovery to Kuffelar, an ingenious dyer of Leyden, who was the first to carry out its manufacture: hence it was called *Kuffelar's Colour*. The process soon reached Van der Gecht and Gulich, who, however, appear to have discovered the process by their own independent investigations. Van der Gecht, in 1550, communicated the secret to the Gobelins, the celebrated tapestry manufacturers. Nearly a century after this, in 1643, one Kepler, who had acquired a knowledge of the process in Flanders (his native country), came over to England, and settled at Bow; where, having practised the dyeing of this colour, it went by the name of *Bow Dye*. Kepler, however, did not carry this process to such perfection as the brothers Gobelin, or, indeed, the dyers of Flanders; nor was the art of scarlet dyeing thoroughly known in England until one Bauer, or Brewer, having been invited to England in 1667 by Charles II., with the promise of a large salary, practised the art in his own manufactory.†—*Brande's Lectures*.

ARTIFICIAL ULTRAMARINE.

Of all the achievements of inorganic chemistry, the artificial formation of Lapis Lazuli was the most brilliant and the most conclusive. This mineral is of a beautiful azure blue colour, remains unchanged by exposure to air or to fire, and furnishes us with the most valuable pigment Ultramarine.

Ultramarine was dearer than gold. It seemed impossible to form it; for analysis had sought in vain the colouring ingredient. It was shown to be composed of silica, alumina,

* The building of London Bridge was commenced, and most probably the piles were driven, in 1176: the Bridge was removed in 1832: so that it stood 656 years.

† Fearn, the eminent lawyer, who was profoundly versed in medicine and chemistry, obtained a patent for dyeing scarlet.

and soda, three colourless bodies; with sulphur and a trace of iron, neither of which are blue; and no other body had been detected in it to which its colour could be ascribed. Yet now, simply by combining in the proper proportions, as determined by analysis, silica, alumina, soda, iron, and sulphur, thousands of pounds weight are manufactured from these ingredients; and this artificial Ultramarine is even more beautiful than the natural, while for the price of a single ounce of the latter we may obtain many pounds of the former.

With the production of artificial Lapis Lazuli, the formation of mineral bodies by *synthesis* ceases to be a scientific problem to the chemist.—*Liebig*.

SIR HUMPHRY DAVY'S ELECTRO-CHEMICAL THEORY OF VOLCANOES.

Potassium is a soft, silver-like metal that melts at 136° , can be distilled at a low red-heat, and kindles in the air at the temperature where it begins to vaporise. In the dry air it quickly combines with oxygen, and is soon covered with a white rust. This is potassa. Potassa attracts the aqueous vapour of the atmosphere, and becomes potash, which draws down more and more moisture, till the original bright bead has become a little pool of alkali dissolved in water. This solution combines rapidly with the carbonic acid of the air; and if it be subsequently boiled to dryness, there is left the carbonate of soda—the pearl-ash of the housewife.

Potassium is lighter than water. It breaks into flame the moment it touches water or ice. If plunged under water, there is no combustion; but hydrogen is discharged with turbulence and resistlessness. These remarkable but far from anomalous properties suggested to Sir Humphry Davy the conjecture that the solid body of the world is composed of potassium and the metals that resemble it; and that volcanic eruptions are produced by the occasional incursion of the waters of the deep, or of the great mountain tanks, in the still domain of these Atlantic metals. The far greater part of the investigated crust of the earth is certainly composed of such oxidated metals, and the specific gravity of the whole globe is supposed to be less than that of even the rocks; so that it is at least possible that there may be more of sound prediction in this sublime conception than the majority are inclined to think.—*North British Review*, No. 3.

It should be added that Davy in the most distinct manner gave up this opinion; but he still asserted that the presence of oxidisable metalloids in the interior of the earth might be a *coöperating* cause in volcanic processes already commenced.

THE NEW METAL ALUMINUM.

This is the metallic base of the earth Alumina, which is composed of oxygen and the metal Aluminium. Sir H. Davy was led to believe alumina to be a metallic oxide; but it was Wöhler who first separated the metallic substance by decomposing the chloride of Aluminium by means of potassium or sodium, when the chlorine unites with the metal employed, and leaves the Aluminium free. Till recently it was procured only in very small quantities, and was regarded as a chemical curiosity. However, in 1857, the Rev. Mr. Reade explained to the British Association that he had digested alumina in a solution of iodine, and thus obtained a semi-white metallic substance; attempting to solve the problem which has so extensively occupied the attention of practical chemists in *extracting the pure metal from its compounds*. Upon this Dr. Lee remarked: "Mr. Reade lives upon the great basin of Kimmeridge and Oxford clay, in the Vale of Aylesbury. He is therefore really the owner of a fortune, lying, however, under his feet, but which only requires the aid of the chemist to transform it into pure metal and current specie."

Aluminium forms an essential portion of some of our most brilliant gems, including corundum, the sapphire, the oriental ruby, and the emerald; and we have a boundless supply of aluminous substances in granite, slates, schist, and especially in clays. Still, the extraction of the metal is a labour of great difficulty. Its oxide, alumina, will not surrender its oxygen to any known fuel, at any known temperature. It has been also stated that the metal itself could resist the highest temperature without absorbing oxygen; but we now learn that if the temperature be raised to a welding heat, Aluminium will burn with great intensity, until a stratum of alumina is formed upon its surface sufficiently thick to exclude the atmosphere.

The first access to Aluminium was opened by Oersted, who, by an ingenious concentration of chemical force, converted the oxide into the chloride of Aluminium, the vapour of which Wöhler decomposed by the vapour of potassium, and thus obtained minute quantities of Aluminium. In 1856, M. Deville simplified the process, and improved the manufacture of sodium (the metal which he employs as the reducing agent), thus greatly diminishing the cost; and in the private laboratory of the Emperor of the French, M. Deville next produced a whole bar of Aluminium.

M. Corbelli has, however, extracted Aluminium directly from clay by dissolving it in acid, heating the earthy matters, then mixing them with yellow prussiate of potash and sea-salt, and

heating them in a crucible until a white colour (the Aluminium) is produced.

Aluminium is extremely light (one-fourth the weight of silver), is more malleable and ductile than silver, and will neither rust nor tarnish. It is very sonorous, and is an excellent conductor of heat and electricity. It is specially adapted for surgical instruments; and, as it is not corroded by acids, is the best-known metal for culinary vessels. Pianoforte strings have been made of it; and it may be used for musical instruments. Could it be more cheaply produced, it would be much employed for coating iron surfaces, as rails and pipes. Spoons and forks and drinking-cups have been made of it, at about half the cost of silver. With gold Aluminium forms an alloy very closely resembling the precious metal. It is used for brooches and studs, bracelets, pins, and combs, pencil-cases, thimbles, seals, and medallions; for spectacles, as it does not blacken the skin like silver; and for reflectors of gas-burners, since it resists the effects of sulphurous emanations, which silver and brass do not. Aluminium would form an excellent substitute for copper coinage; with iron it forms an alloy of hardness superior to bronze; with copper it dips a fine golden colour in nitric acid. Its alloy with nickel is more fusible and harder than the pure metal. If Aluminium be fused with oxide of lead, a violent detonation ensues, the crucible breaks into pieces, and even the doors of the furnace are driven to a distance.

M. de Lille, of Paris, has obtained from cryolite (a fluoride of Aluminium and of sodium, found only in Greenland) the metal Aluminium at as low a price as silver; and since an ounce of the former has four times the volume of an ounce of the latter, it will of course give articles of plate of the same size at one-fourth the price. Cryolite also yields crystals of soda, and a calico valuable to calico-printers.

Mr. Gerhard has obtained the metal most economically by combining in an oven hydrogen gas with the fluoride of Aluminium, and forming hydrofluoric acid, which is taken up by iron, and thereby converted into fluoride of iron; whilst the resulting Aluminium remains in the metallic state in the bottom of trays containing the fluoride. Dr. M'Adam placed Aluminium medals in a solution of caustic potash, when hydrogen was evolved; the surface of the metal became beautifully frosted, and did not afterwards become tarnished.

ALUM IN BREAD.

Dr. G. Wilson, in his paper on "Chemical Final Causes," shows the unsuitableness of Aluminium to the organism, and the cause of our failure in its detection. Aluminium (he says)

forms only a peroxide, alumina; so that it is an unpliant, unaccommodating metal. Alumina, moreover (the dyer's most useful mordant), has so excessive an attraction for organic matter, with which it forms insoluble compounds, that it cannot take an active part in organismal changes. In truth, when taken internally, it is prevented, by this precipitation in an insoluble form along with the first organic substance which it encounters, from entering the blood, except in minute quantity, and it is not retained there. (Lehmann's *Physiol. Chem.*) If, indeed, there is any justice in the statement that bakers are in the habitual practice of adding alum to bread, we must be continually swallowing alumina; yet none is found in our blood.

Liebig considers that when alum is added to bread, the soluble phosphates, which the flour largely contains, are decomposed, the phosphoric acid of the phosphates unites with the alumina of the alum, and thus an insoluble phosphate of alumina is formed, while the beneficial action of the phosphates is consequently lost to the system.

Alum works were introduced into England towards the close of the 16th century, when Thomas Chaloner (afterwards Sir Thomas, and governor of Prince Henry, son of James I.), while travelling in Italy, observed that the natural appearances of the country at Puzzeoli, where the Pope had his alum-works, were similar to those on his estate near Gainsborough in Yorkshire. He therefore induced some of the Pope's workmen to accompany him to England; in order to smuggle them away, he put two or three of the men into casks, and in this manner had them conveyed to a ship which was ready to sail. The enraged Pope (to whom England had been previously indebted for its supply of alum) then visited Chaloner with excommunication; and his curse is to be found in Charlton's *History of Whitby*, word for word the same as that read by Dr. Slope in *Tristram Shandy*. Sterne used often to visit his friend John Hall Stephenson (the Eugenius of his story) at Skelton Castle, near Gainsborough, and there became acquainted with the curse in question, which is familiarly known in the neighbourhood.

COPPER.

This metal occurs in the greatest number of places, and in the largest quantity, in the north of Europe, in England and Wales, in many parts of Asia and Africa, and in South Australia and Chili.

The Greeks were well acquainted with copper as *chalcus*: it was used by them, alloyed with tin, for cutting and warlike instruments before iron was known, or at any rate before it was common. Our name, Copper, is said to be derived from the island of Cyprus, where Tamassus was once famous for its copper-mines, in the early colonisation by the Phoenicians. Copper may be reduced to very thin leaves, as we see in Dutch tal, an alloy of 11 copper and 2 zinc rolled into sheets,

chiefly at the brass-works of Hegermühl. It may also be drawn into very thin wire. After iron and platinum, it is the most tenacious metal: a wire $\frac{1}{1000}$ of an inch in diameter supports a weight of 302 pounds without breaking. It is a good conductor of electricity: hence the wires of electric telegraphs are of copper.* It is extremely sonorous,—hence it forms three-fourths of *bell-metal*. *Brass* is copper and one-third zinc; *gun-metal*, 90 copper and 10 tin; *speculum-metal*, copper and a larger proportion of tin; and *bronze*, 91 copper, 2 tin, 6 zinc, and 1 lead; but the brass of the ancients was copper and tin. *Tutenag* was copper, zinc, and a little iron; *Prince Rupert's metal* and *Pinchbeck*, more copper than in brass; *Manheim gold*, 3 copper and 1 zinc; and *Packfong*, or *White Copper of China*, is an alloy of copper, nickel, and zinc, named German Silver, and used for spoons, forks, &c.

In 1660, when the Royal Society conducted their own experiments, and had their own assay-furnace, we find this entry of an experiment by Sir William Persall:

Take a handful of the powder of Roman vitriol (sulphate of copper); put it into a gallipot, in a pint of water; put in two or three small irons the length of a span, and three or four times a day constantly stir the water and powder, and move not the irons at all, but let them stand constantly in night and day; within the space of three weeks there will be crusted about the irons, as far as they are in the water, a substance purer than copper, which you may take off, and will be malleable. Such a result would now be shown by a lad as a piece of “parlour magic.”

Copper vessels for cooking, if kept clean, are not dangerous, provided whatever is boiled in them (unless of an acid nature, which will always form some dangerous compound) be not allowed to stand to cool in the vessel, but be instantly poured out. Tinning the insides of copper vessels affords protection so long as the tinning remains entire; but if they be silvered by the electro process, they are acted upon by weak acids, lemon-juice, and vinegar, arising from the deposited silver being so porous as to allow the acids to permeate its substance; and the action is most likely assisted by the formation of a galvanic circuit. In such cases copper has been detected.

The most beautiful carbonate of copper is the mineral Malachite of emerald green, extensively used for veneering and inlaid work. Sir Roderick Murchison considers Malachite to be a subterraneous incrustation produced during a succession of ages by copper solutions trickling through the surrounding loose and porous mass to the lowest cavity upon the solid rock at the bottom of one of the shafts of the copper-works of the Ural.

* In 1853, a piece of Copper, weighing about 123 pounds, was drawn out at Walker's mills, Birmingham, to a length of upwards of four miles, to be laid down as a line of telegraph, without link or weld.

LEAD.

This abundant metal is employed to cover buildings, to form water-pipes (though Vitruvius, the Roman architect, condemned this practice), and to make vessels for economical purposes. Pigs of lead have been dug up in England with dates and inscriptions proving this metal to have been used here in the time of the Romans. This people, as well as the Greeks, proved the quality of their wines by dipping a plate of lead in them : they knew that it rendered harsh wine milder, but not that the metal was poisonous.*

Lead is used in refining the precious metals because, when mixed with them in a great heat, it rises to the surface, combined with all heterogeneous matters. The oxides of lead are used in dyeing and calico-printing, in the manufacture of glass, earthenware, and porcelain. Lead combined with a little arsenic is made into shot, in lofty towers : the liquid metal is let fall like rain from the top of the tower ; the drops in their descent become truly globular, and before they reach the end of their fall are hardened by cooling, so that they retain their round shape.

Red-lead is obtained by melting common lead exposed to atmospheric air ; white-lead by exposing sheet-lead to acetic acid. Pewter consists of 80 parts tin and 20 lead.

A commission of German chemists have determined, after long research, that snuff wrapped in lead, even when covered with paper, or combined with tin, gradually becomes poisonous by acting upon and taking up the metal.

THE LEAD-TREE.

The common but very pleasing experiment of the Lead-Tree, is greatly dependent on electro-chemical action. When a piece of zinc is suspended in a solution of acetate of lead, the first effect is the decomposition of a portion of the latter, and the deposition of metallic lead upon the surface of the zinc ; it is simply a displacement of a metal by a more oxidisable one. The change does not, however, stop here : metallic lead is still deposited in large and beautiful plates upon that first thrown down, until the solution becomes exhausted or the zinc entirely disappears. The first portions of lead form with the zinc a voltaic arrangement of sufficient power to decompose the salt : under the peculiar circumstances in which the latter is placed, the metal is precipitated upon the negative portion, that is, the lead, while the oxygen and acid are taken up by the zinc.—*Fownes's Manual of Chemistry*.

* Leaden moulded pipes were used in Cardinal Wolsey's time for conveying water $3\frac{1}{2}$ miles from a spring in Surrey, beneath the bed of the Thames, to Hampton Court Palace.

PLUMBAGO, OR "BLACK-LEAD."

Plumbago, erroneously termed "Black-lead," is chiefly composed of carbon with some admixture of other substances, not unfrequently iron. Its importance for the arts and crucibles is well known. After the Borrowdale mines in Cumberland were somewhat exhausted, it became important, for that variety of plumbago employed in art, to obtain some substitute. Several compounds were invented; but nothing succeeded so well as the compressing process patented by Mr. Brockedon, by which much of the Borrowdale Plumbago-dust has been utilised with advantage. It, or any other good plumbago, is ground into fine powder, placed in packets, and then receives a pressure equal to about 5000 tons. To prevent the injurious effects of disseminated air in the packets of fine powder, it is extracted by means of an air-pump; and thus the particles themselves can be brought into close juxtaposition, and forced to cohere.

TIN.

This valuable metal occurs in South America and Malacca, in Saxony and Bohemia, and more especially Cornwall. To this part of our island the Phœnicians came to procure tin and lead, and in return gave salt, earthenware, and copper goods. (*Strabo*.) Hence the western extremity of Britain, with the Scilly Isles, were called the Casseritides, or "Tin-islands," from a root which in some of the Oriental tongues, as well as in the Greek, denotes Tin. The Greeks appear to have known these Tin-works before the time of the Roman conquest of our island. According to Aristotle, the Tin-mines of Cornwall were known and worked in his time: Diodorus Siculus describes them; and the Romans mixed Tin with their copper coins and edge-tools, which are found here.

Tin, dissolved in acids, is much used by dyers for reds and scarlets; and the Purple of Cassius (Tin combined with gold) is employed in enamel-painting and in staining glass. (See "Discovery of Scarlet Dye," p. 118.)

ZINC

Is frequently called in commerce *Spelter*, and was first mentioned by Paracelsus, in the sixteenth century, under the name of *Zinetum*. It is the most combustible metal we have: if beaten out into thin leaves, it will take fire from a common taper. It is much used for roofs in the Low Countries; but in case of fire, the zinc being very combustible, is extremely liable to become inflamed, and, falling around, occasions great danger to those who approach the building. Plates of Zinc are much

employed in voltaic batteries. With copper it forms brass. Zinc is much used for coating iron to prevent rusting, and Zinc milk-pans increase the quantity of cream; but if the milk becomes sour while in them, the acid acts upon the Zinc, and forms unpleasant if not poisonous compounds. Zinc in the purely metallic state produces no effect upon the human system, but in combination with oxygen its medical properties are numerous and important.

PLATINUM,

In the language of Peru "little silver," was originally discovered at two places in South America, in New Granada and at Barbacoas. It has been found in considerable quantities in the Ural mountains, and is used for coinage in Russia. It has also been met with in the metamorphic district of the valley of the Drae, department of Isere. It has likewise been found in combination with gold in California; and in 1855 it was estimated that as much as 5300 ounces of Platinum must have been conveyed in this way to the Atlantic States.

Platinum, the heaviest body in nature, is incomparably hard. In the mass it is lustrous white, but may be so finely divided that its particles no longer reflect light, and it forms a powder as black as soot. It will then absorb more than eight hundred times its volume of oxygen gas, and this oxygen must be contained within it in a state of condensation greater than that of liquid water. If a drop of absolute alcohol be let fall upon the Platinum, inflammation will immediately ensue, and the metal will become incandescent.

Dr. Wollaston obtained very fine Platinum wire for the object-glasses of his telescopes, for observing the relative places of the stars, by inserting Platinum wire in a cylinder of silver, wire-drawing the whole, and then melting the silver coating. Now silver wire may be drawn to the three-hundredth of an inch diameter; so that if the Platinum wire was originally one-tenth of the thickness of the silver, it then became only the three-thousandth of an inch. Dr. Wollaston procured some only an eighteen-thousandth, which did not intercept the smallest star. Very fine Platinum wire is also employed as a substitute for hair in making forensic wigs.

It is calculated that a piece of Platinum the size of the tip of a man's finger could be drawn out across Europe.

Platinum is made a fulminate as follows: The triple sulphate of Platinum and ammonia is boiled in a solution of potash; when the sulphuric acid unites to the potash, a portion of the ammonia is evolved, and the remainder, entering into intimate union with the oxide of Platinum, produces fulminating

Platinum. Its explosive powers may be referred to the sudden extrication of nitrogen, ammonia, and aqueous vapour.

Dr. Wollaston, in 1828, transferred a large quantity of Platinum and Palladium to the Council of the Royal Society, to be given "in aid of chemical experiments." A portion of this Platinum has been employed in the construction of a Standard Troy Pound, which is preserved in the Instrument Room of the Royal Society. Dr. Stukely in his Ms. Journal says, under the date of Dec. 13, 1750: "A piece of Platinum was presented to the Society. It is called *Platina del perito*, because of its silvery colour. The Spaniards sell it very dear, and make knife-handles, sword-handles, and many toys of it; it bears a good polish, and is not apt to tarnish. I guess it would be good for speculums to reflecting telescopes."

Dr. Wollaston's name is intimately connected with several chemical discoveries of the highest importance. "In 1804 and 1805, he made known palladium and rhodium,* two new metals contained in the ore of platinum, and associated with osmium and iridium, discovered about the same time by Mr. Tennant. In 1809 he showed that the supposed new metal, tantalum, was identical with columbium, previously discovered by Mr. Hatchett; and shortly before his death he transmitted to the Royal Society a communication, constituting the Bakerian Lecture for 1828, in which he fully describes his ingenious method of rendering Platinum malleable. (*Brandé's Manual of Chemistry*, p. 102.) By this invention he is stated to have acquired more than thirty thousand pounds."—*Weld's History of the Royal Society*, vol. ii.

ORIGIN OF CORINTHIAN BRASS.

It was during the mighty conflagration of Corinth, A.U.C. 608, that the celebrated amalgam called Corinthian Brass is said to have been first formed; gold, copper, and silver, having melted and flowed together into one precious mass, which was considered in future ages as more valuable than pure gold. This is, however, thought to be an historic fiction; for another account states the city to have been sacked before it was fired; in which case the Brass may have been a recent discovery of the Corinthian people, and the Romans may have plundered the foundry of its contents.

* The successful application of rhodium for the nibs of metallic pens, on account of its extreme hardness and durability, was made by the suggestion of Dr. Wollaston.

Poisons.

POISONS OF THE ANCIENTS.

SIR Henry Hallford, in one of those delightful papers in which he was wont, as Mr. Pettigrew has gracefully said, to "display the elegant scholar and observant physician," has left us the following curious investigations in the death of celebrated characters of antiquity, with special reference to the knowledge of Poisons possessed by the ancients.

Sylla died in consequence of the rupture of an internal abscess, through an excess of rage ; which, according to Valerius Maximus, produced a violent vomiting of blood, and death.

Crassus, the eminent lawyer and friend of Cicero, died of pleurisy ; and the course of treatment for this disorder, prescribed by Celsus, and in use at the time,—namely, bleeding, cupping, and blistering,—was so similar to that pursued at the present day, that nothing was probably left undone that could have saved his valuable life.

Pomponius Atticus, whom Cicero loved as a brother, and who was on friendly terms with all parties in the disturbed times in which he lived, was said to have died of a fistula in the loins ; it was probably, Sir Henry thinks, a dysentery ending, as that disorder commonly does, in an affection of the lower bowels. He had recourse to starvation, a very common expedient amongst the Romans, and died in ten days, aged seventy-seven.

The latter end of Socrates was brought about by the common mode of despatching persons capitally convicted at Athens, namely, by a narcotic poison ; but neither Xenophon nor Plutarch tells us the species of poison. The poisons of this class known to the ancients were aconite, white poppy, hyoscyamus, and hemlock. The black poppy might be the Theban-drug. The hyoscyamus was used at Constantinople, and was very likely the *Nepenthe* spoken of by Homer. But most probably the poison administered to Socrates was the same as that given to other condemned criminals, namely, *scilla*, *cicuta*, hemlock. Juvenal attributes his death to hemlock :

" Dulcique senex vicinus Hymetto,
Qui partem acceptæ sæva inter vincla cicutæ."

Whatever may have been the species of poison, it was one of weak and slow operation, for the executioner told Socrates that if he entered into earnest dispute, it would prevent its effect ; and it was sometimes necessary to repeat the dose three or four times. Its operation was gradually to produce insensibility, coldness of the extremities, and death.

Mr. Petit, in his *Observations Miscellanæ*, remarks that the advertisement was not given by the executioner out of humanity, but to save *cicuta* ; for he was only allowed so much poison per annum ! which he exceeded, he was to furnish the rest at his own expense. This

construction is confirmed by the circumstances as related in Plutarch nearly as follows. When Phocion and his four colleagues, condemned for treason at Athens, were led out to have the customary dose of poison administered, and all had drunk except Phocion, no more hemlock was left; upon which the gaoler said he could not prepare any more unless twelve drachmæ of money were given him to buy the material. Some hesitation took place, until Phocion asked one of his friends to supply the money, sarcastically remarking, that it was hard if a man could not even die *gratis* at Athens.

What was that poison by which Hannibal destroyed himself? It is improbable that we shall ever know. Modern chemistry has discovered a variety of subtle poisons that may be introduced into a ring, and, under certain circumstances, destroy life. One drop of Prussic acid may produce paralysis, and, if taken into the stomach, may instantly arrest the current of life. But it was not likely that the Carthaginians were acquainted with Prussic acid; Lybia most probably produced poisons sufficiently subtle and destructive to accomplish the fatal purpose of Hannibal. The report of its being bullock's blood must be a fable, as well as in the case of the death of Themistocles, for it is well ascertained that the blood of that animal was not poison. An accomplished nobleman told Sir H. Halford that he had been present at a bull-fight in Spain, when, after the matador had killed the bull, a person ran up, caught the animal's blood in a goblet, and drank it off, as a popular remedy for consumption.

[Hannibal carried poison in his sword, to despatch himself if he should happen to be surprised in any great extremity; but the sword would have done the feat much better and more soldier-like. And it was below the honour of so great a commander to go out of the world like a rat.—*Butler.*]

With respect to the poison with which Nero destroyed Britannicus, comparing the account given by Tacitus with the effects of laurel-water, Sir Henry was disposed to think that this was the identical drug. It appeared that the Emperor applied to Locusta, a female poisoner, to procure some vegetable poison that would kill speedily. She produced one which destroyed a goat in five hours. Nero, however, required a poison which would kill instantly, and she procured such an ingredient. At the banquet, Britannicus called for water, which the *pregustator* tasted; it was not sufficiently cool; part was then poured off, and the fatal liquid added; the young man drank, was seized with an epileptic fit, and expired. The case is analogous in the effects with that of Sir Theodosius Boughton, who was poisoned by Donellan with laurel-water, and fell down in an epilepsy. In the case of Britannicus, Nero told the company that the young man was liable to such fits; and in the other case, Donellan said that Sir Theodosius had been subject to fits from his infancy. Tacitus mentions a blackness which came over the body of Britannicus; and Sir Henry stated that he was present when the corpse of Sir Theodosius Boughton was disinterred, and its colour resembled that of a pickled walnut. If we could suppose that the Romans were acquainted with the deleterious property of laurel-water, and with the process of distillation, there could be no difficulty in concluding that Britannicus was poisoned with laurel-water. It is true the species of *laurus* which yielded the deleterious liquid did not grow in Italy; but it was a native of Colchis, from whence it might have been brought. The *laurus nobilis* (daphne) grew about Rome, and was used in producing the inspirations of the prophetic priestesses. As to the knowledge possessed by the Romans of the art of distillation,

they had not, indeed, a still and refrigeratory like the moderns ; but they received the vapour from the boiling herbs in a handful of sponge, which, though a rude, was not an inefficient substitute.

Alexander the Great is said to have been poisoned ; but this is inconsistent with the very detailed account of his illness given by Arrian. The report was, that the poison was sent by Antiphon, and was of such a peculiar nature that no silver or metallic substance would contain it, and it was conveyed in the hoof of a mule. But the article was really onyx, as Horace says : now the word *onyx*, in Greek, signifies not only a stone, but *unguis*, a hoof or nail ; and the second sense has been evidently given instead of that of a precious stone. Alexander really died of a remittent fever caught at Babylon. As to the cause of it, Arrian expressly states that the king was temperate and forbearing in the pleasures of the table ; and when we consider the laborious occupations of Alexander, amidst frost and snow, and especially the marsh miasmata of the Babylonian lakes, Sir Henry thought there was no difficulty in conceiving that this was too much even for his frame of adamant. The diary of Arrian, containing the details of Alexander's illness and death, vindicates his memory from the imputation of his having brought on his fate by intemperance. Sir Henry Halford closed his learned and interesting paper by a brief encomium upon the character of Alexander, in the course of which he remarked that the efficiency of the British army in India, which kept millions of natives in subjection, was maintained by the same measures which Alexander devised and executed.

Mr. Grote, in his *History of Greece*, maintains that the cause of the fever of which Alexander died was intemperance.

Sir Thomas Browne thus notices the reputed poisoning of Alexander : " Surely we had discovered a poison that would not endure Pandora's box, could we be satisfied in that which for its coldness nothing could contain but an ass's hoof, and wherewith some report that Alexander the Great was poisoned. Had men derived so strange an effect from some occult or hidden qualities, they might have silenced contradiction ; but ascribing it unto the manifest and open qualities of cold, they must pardon our belief, who perceive the coldest and most Stygian waters may be included in glasses : and by Aristotle, who saith that glass is the perfectest work of art, we may understand they were not then to be invented."—*Vulgar Errors*, b. vii. c. xvii.

DEATH OF CLEOPATRA.

Cleopatra was present at the decisive battle of Actium, September 2, 31 B.C., and she set the example of flight, which was followed by Marc Antony. He attempted suicide, but the wound did not produce immediate death. Cleopatra, when she heard the cries of anguish, and recognised the voice of Antony, despatched a messenger to bid him to join her in her tower, whither she had retreated. Antony, pale and bleeding, was raised into the tower by a rope, and here he breathed his last, in the arms and upon the lips of Cleopatra. She then committed suicide, in order to avoid the humiliation of being led in the triumphal procession of Octavianus. Most probably she took poison. According to the story in Plutarch, she was closely watched by the order of Octavianus, who suspected her

design ; but an asp, the reptile she had chosen for her purpose, was brought her by a peasant in a basket of figs. After using her bath, and partaking of a sumptuous supper, she applied the deadly serpent to her arm. Before retreating to her monument or tower, she wrote to Cæsar, who discovered in the tone of her address an earnest of her secret resolution. He despatched his guards in haste ; but Cleopatra was no more. When the door of her apartment was burst open, she was dead ; her beauty was yet unimpaired. She lay beneath a canopy of white Pelusian, dropped with gems, upon a golden couch of gorgeous workmanship, attired in all the ornaments of royalty ; one of her attendants lay dead by her side, and the other had just strength enough remaining to arrange the diadem on the head of her mistress.

The *Asp* has thus obtained celebrity as the instrument of death selected by Cleopatra. It is often mentioned both by Greek and Roman writers : its modern Arab name is *El Haje*, and it is closely allied to the cobra capello, or spectacled snake of India. Its poison is of the most deadly nature. The habit which this serpent has of erecting itself when approached, made the ancient Egyptians imagine that it guarded the place which it inhabited. They made it the emblem of the divinity, whom they supposed to protect the world ; accordingly, they have represented it on their temples sculptured on each side of a globe.

POISON-RINGS OF THE ANCIENTS.

Many cases are recorded of suicide by the ancients by means of rings made with hollow beads to receive a small drop of concentrated poison, of the class called acro-narcotic. Thus, M. Crassus, when arrested on a charge of purloining from the temple of Capitoline Jove an immense amount of gold deposited there by Camillus, broke the hollow receptacle of his ring between his teeth, and falling, expired on the spot. Hannibal's death is said to have been occasioned by a ring :

Not the swift sling nor strenuous spear shall harm
The life that held the nations in alarm ;
A ring, behold, the debt of vengeance pay,
And all the blood which blends with Cannæ's clay.

And to mention but one other instance, the illustrious Demosthenes met his death in a like manner, and for a like reason.

THE POISON-BOWL OF CAPUA.

On the night before Capua capitulated to the Romans, seven-and-twenty of the chief nobles of that city were invited by Vibulus Varius to a funeral feast, in anticipation of their own death. After supper, when they were filled with meat and drink, the host, himself setting the example, quaffed a bowl of poison, and then handed it round to his guests, who drank each man

his share ; and after a final embrace, all separated. Some died that night, many early in the morning ; but the whole band had ceased to exist before the Romans forced a way into Capua the next day.—*Fraser's Magazine*, No. 317.

POISONING BY ARSENIC.

We have already glanced at the properties of metallic Arsenic, and now propose to consider a few of the effects of its compounds rendered serviceable in medicine ; but science has unfortunately enabled wicked men to increase and multiply the means of its employment as a poison, and at the same time to baffle detection by the most subtle art.

The white arsenic of the druggists is the arsenious acid ; it has not the garlic smell, and is a virulent poison, which is not the case with the metal. The detection of arsenious acid in complex mixtures containing organic matter and common salt, as beer, gruel, soup, &c., or the fluid contents of the stomach in cases of poisoning, is a very difficult problem ; the organic matters rendering the indications of the liquid tests worthless.

Marsh's method is extremely delicate. The suspected liquid is acidulated with sulphuric acid, and placed in contact with metallic zinc ; the hydrogen reduces the arsenious acid and combines with the arsenic, if any be present. The gas is burned at a jet, and a piece of glass or porcelain held in the flame, when any admixture of arsenetted hydrogen is at once known by the production of a brilliant black metallic spot of reduced arsenic on the porcelain. (*Fownes's Manual*.) The zinc and the sulphuric acid should be previously examined in the apparatus, as they often contain traces of arsenic.

Reinsch's test with copper-wire is also very delicate. By dissolving a grain of arsenious acid in a pint of distilled water, arsenic has been detected at a dilution of 560,000 times ; and at 280,000 times the liquor is so strong as to be fit for sublimation, having a bright steel colour.

White arsenic is generally said to be in taste acrid and corrosive ; but Dr. Gordon states it to be *at first* always sweet, but afterwards somewhat acid. It is not so poisonous as Prussic acid and strychnia, while its curative influence is very great. A small quantity, as $\frac{1}{16}$ or $\frac{1}{32}$ of a grain, acts as a tonic ; but this statement should not lead any one to make a hasty or inconsiderate use of this very powerful agent, which should be left in the hands only of the most skilful medical practitioners. Before its regular introduction, combined with potass, it was employed in Lincolnshire for the cure of intermittent fevers, under the name of the *Tasteless Ague Drops*. In rheumatisms, neuralgia, heart-burn, epilepsy, hydrophobia, tetanus, cancer, and skin-diseases, arsenic is given by regularly-educated practitioners, but should never be used as a domestic or household medicine.

Marvellous stories are related of the common people *eating arsenic* in Lower Austria and Styria, and thus giving plumpness to the figure, and beauty and freshness to the complexion, and easy breathing to persons climbing steep and continuous heights. We have known arsenic given to horses among their corn, to improve their coats and condition; here it is a stealthy practice, but in Austria it is openly followed.

The want of care and exactness in the quantity of arsenic, and the frequent change of servants, have doubtless occasioned the loss of many valuable horses, whose deaths have remained a mystery; for it is a wonderful fact with regard to the taking of arsenic, that if it be discontinued, the constitution breaks up with precisely the same symptoms which are produced by arsenical poisoning; and the sufferer (the effect is the same on the man as on the horse) dies a miserable death from want of arsenic, with every appearance of being the victim of poison.

The subject is, however, beset with contradictory evidence. At the meeting of the British Association in 1859, a remark made by Mr. Trevelyan, that it was the opinion of some that arsenic, when taken in small quantities, was not deleterious, brought forth a warning from Professor Daubeny, not to put any faith in the statement in Dr. Johnston's *Chemistry of Common Life*, that arsenic is taken by the girls of Tyrol to improve their complexion, and that when taken constantly the system becomes used to it, *that* being the reverse of the fact. Mr. Liveing observed, he had heard this use of arsenic had been told to Dr. Johnston by a practical joker, who did not like to confess the imposition after it had been made public. Now, in Johnston's work, vol. ii. pp. 201-204, Dr. Von Tschudi, the traveller, is quoted as the authority.

Arsenic has been detected in vinegar, conveyed in the sulphuric acid with which vinegar is adulterated. To diminish the crystallising force of fatty acids in candle-making, arsenious acid was formerly employed; but the "arsenic candles" were soon driven out of consumption, and the manufacturing effect is now produced by regulation of temperature. The arsenic of copper in green paper-hangings is liable to be blown or brushed off, dispersed in the apartment, and inhaled. Prof. Lain, of Besançon, has proved there to be arsenic in the wire of which pins are made, three or four giving a perceptible quantity: * "never put pins in your mouth." Fly-paper, "Papier Mouré," has been found to bear arsenious acid enough in four sheets to destroy a human life. Artificial Manures (as superphosphates) being prepared with sulphuric acid which contains arsenic, it may be absorbed by plants grown with such manures,

* Possibly this may be from the sulphuric acid in the *pickle* for the pins.

and the poison be thus conveyed into our systems. Arsenic has long been used in steeping grain for seed; when it preserves the seed from decay, kills the vermin which might devour it, and converts them into manure. Arsenite of copper, used for colouring confectionery green, has poisoned many children. Shot (arsenic and lead), from being left in wine-bottles in washing, and afterwards dissolved in wine, has often produced colic in the drinkers, if not death.

Orfila at one time thought he had satisfactorily proved arsenic to be a normal constituent of the bones of man; an opinion which, if confirmed, would have gone far to render inoperative chemical testimony in relation to the unfair or criminal presence of that body. Orfila subsequently altered that opinion; but more recent chemical investigators have demonstrated the presence of arsenic in sources where it would have been little suspected. Amongst others, that metal has been proved to exist invariably in the ochreous deposits which certain varieties of natural water throw down. Cognisant of this fact, Prof. Otto, of Brunswick, examined for arsenic the crust which had formed inside his tea-kettle; and by the application of Marsh's test he proved the presence of arsenic. The water used in London deposits a large amount of crust in tea-kettles: it holds a variable portion of oxide of iron, and probably, if subjected to chemical tests, it will be found to contain arsenic.

In a paper in *Silliman's Journal*, 1859, it is stated that the larvæ which consumed some rats that had been poisoned with arsenic and flyblown, were not affected by it, although it is well known that flies themselves are quickly destroyed by arsenic.

HOW THE NETTLE STINGS.

Prof. Wills, of Giessen, having ascertained the liquid in the poisonous organs of some insects to be *formic acid*, considered it probable that the same acid occurred in plants, which by their stinging hairs produce effects analogous to the sting of certain insects. Acting on this suggestion, Dr. Gorup-Besanez has detected formic acid in various stinging-nettles. It exists in minute quantities, and is supposed to be contained only in the stinging hairs, from its being observed that when a solution of silver is applied to the plant under the microscope, with a gentle heat, reduction always first occurs at the extremity of the stinging hair. In other words, this is done by the cuticle of the plant being extended into rigid hairs or bristles, which have venom at their root, and a portion of which is conveyed through them into the wound they inflict. The construction of this sting may be considered analogous to that of the serpent. Mr.

Curtis, in his *Flora*, has thus minutely described the stinging process :

The naked eye readily perceives the instruments by which the nettle instils its poison ; but a microscope of no great magnifying power more plainly discovers them to be rigid, transparent, tubular setæ, prickles, or stings, highly polished, and exquisitely pointed, furnished at their base with a kind of bulb, in which the juice is principally contained ; and which, being pressed on when the sting enters the skin, forces the poison into the wound.

"Of the venomous quality of this liquid I have had ocular proof. Placing the foot-stalk of a nettle-leaf on the stage of a microscope, so that the whole of the prickle was in the focus when horizontally extended, I pressed on the bulb with a blunt-pointed pin, and after some trials found a liquid to ascend in the prickle, somewhat as the quick-silver does when a warm hand is applied to the bulb of a thermometer. In some of the prickles I observed the liquid stationary. Or pressing such in particular, I saw most plainly the liquid ascend to, and flow most copiously from, its very extremity. I was the more anxious to see this, as I suspected the poison might proceed from an aperture in the side of the sting near the point, as in the forceps of the spider and tooth of the viper ; and here it appears to be placed, rather than at the extremity, that it may not take off from its necessary sharpness. Pricking the skin of my hand with a needle, I placed some of the juice in the wound, when it instantly inflamed, and put on all the appearance of a part stung by a nettle."

Yet the soft and fleshy caterpillar crawls and feeds on the nettle with impunity, reminding us how the Giver of all good "tempers the wind to the shorn lamb."

The effects of the European nettle are not, however, to be compared with those of some Indian species. M. Leschesnault describes a nettle at Calcutta, the pain from the sting of which lasted nine days. The sensation, when water was applied to the stung part, is described as if boiling oil had been poured over the skin. Still more virulent, however, is the sting of the nettle in Timor, the largest of the Lesser Sunda Islands ; its effects being said by the natives to last for a year, and sometimes even to cause death.

HYDROCYANIC, OR PRUSSIC ACID,*

Discovered as early as 1782, by Scheele, has a very powerful odour, much resembling that of peach-kernels or bitter-almond oil. In the anhydrous state, this substance is one of the most formidable poisons known ; and even when largely diluted with water, its effects upon the animal system are exceedingly energetic. It is employed, however, in medicine in very small doses. The acid in its pure state can scarcely be preserved even when enclosed in a carefully-stopped bottle ; it soon darkens, and eventually deposits a black substance con-

* See *ante*, page 85.

taining carbon, nitrogen, and perhaps hydrogen; ammonia is formed at the same time, and many other products. Light favours this decomposition.

Bitter almonds, the kernels of plums and peaches, the seeds of the apple, the leaves of the cherry-laurel, and various other plants belonging to the great natural order *Rosaceæ*, yield on distillation with water a sweet-smelling liquid, containing hydrocyanic acid. This is probably due in all cases to the decomposition of the *amygdalin*, preëxistent in the organic structure. The change in question is brought about in a very singular manner by the presence of a soluble azotised substance, called *emulsin* or *synaptase*, which forms a large proportion of the white pulp of both sweet and bitter almonds. Hydrocyanic acid exists ready formed to a considerable extent in the juice of the bitter cassava.

We are perhaps most familiar with hydrocyanic acid in the smell of the wall-flower and hawthorn. It exists in the leaves of the common laurel so largely, that a water distilled from this is almost instantaneous poison. This fact was discovered at Dublin in 1728 (fifty-four years previous to Scheele's discovery), where several persons who had used it as a cordial, mixed with spirits, were poisoned. Yet the flavouring so commonly used for custards and farinaceous puddings contains a large proportion of this deadly poison.

Prof. Santi, of Pisa, many years since wrote an interesting little work to show that ratafia had long been made with Italian laurel-leaves. Kirschwasser is drawn from the stones of cherries chiefly grown in the environs of the Black Forest: according to Le Normand it is "downright" poison. In Paris, a spurious Kirschwasser is distilled from the kernels of prunes.

The only immediate remedy, of safe application by a non-medical person, for poisoning by Prussic Acid, or any vegetable substance containing it, is pouring a stream of cold water from some elevation upon the head and spine of the patient. The lives of many have been saved by this very simple means being resorted to immediately, while the delay of a few minutes would have proved fatal. The effect of this poison is narcotic; and owing to its rapid action on the nervous system, a convulsive contraction of the muscles of the jaw generally prevents the administration of emetics.*

Cyanide of Potassium, one of the compounds of this class, is used in considerable quantity in electro-plating and gilding, and has lately been derived from a curious and unexpected source. In some of the iron-furnaces of Scotland, where raw

* From *British Poisonous Plants*. By Charles Johnson, Botanical Lecturer at Guy's Hospital. With coloured plates. Sowerby: Lambeth. (This is an excellent work of authority.)

coal is used for fuel with the hot-blast, a saline-looking substance is occasionally observed to issue in a fused state from the tuyere-holes of the furnace and concrete on the outside: this proves to be cyanide of potassium.

STRYCHNINE AND STRYCHNOS.

Strychnine, or Strychnia, is usually prepared from the peltate seeds of Strychnos, which are commonly termed Nux Vomica, rat's-bane, poison-nut, or Koochta. Strychnos is a tropical bush, growing to the size of a tree, on the Malabar and Coromandel coasts of the Indian peninsula. It bears a cluster of minute flowers and small orange-like fruit. The seeds are imbedded in a white gelatinous pulp, which seems harmless, being greedily eaten by many sorts of birds. The seeds alone form the fatal drug. The wood of the tree is, however, intensely bitter, and is employed in the cure of intermittent fevers and the bites of venomous snakes; indeed, Strychnine itself is an important remedial agent. In very small and repeated doses it promotes the appetite and assists the digestive process. It is employed medicinally in paralysis, dyspepsia, dysentery, affections of the nervous system, &c. In India, the seeds were used in Dr. Roxburgh's time to increase the intoxicating quality of country spirits. At Jellalore, in the Zillah of Midnapore, East Indies, the bush grows (as to its berries) in great and wild abundance. It is remarkable for its encouraging the most deadly snakes amid its branches: here the *cobra capello* takes up its abode.

From the bark of the root of the *Strychnos tienté* is obtained "the frightful poison" called "tjettek," and "upas radja." Another species is employed by the American Indians to poison their arrows; it causes immediate death when introduced into the slightest wound. This plant is also the "upas-tree" of Java;* but being a climbing plant, is different in general habit and botanical characters from the half-mythical upas of which so many fearful fables of death are narrated. The name of Upas has, however, become associated with a great number of poisonous trees throughout Asia. The true Upas-tree is the *Antiaria toxicaria*, which yields the Antiar poison; but the seeds are wholesome. Its venom is due to the same chemical substance, Strychnine, which constitutes the *Strychnos nuxvomica*. Dr. Lindley observes that, although much error has been written regarding the Upas, there remains no doubt that it is a plant of extreme virulence; even linen fabricated from its tough fibre being so acrid as to verify the story of the shirt of Nessus, for it excites the most distressing itching if insufficiently prepared.

* See "The Upas-tree of Java," *Things not generally Known*, First Series, p. 99.

Strychnine is used medicinally in very small quantities, and has no other legitimate application. Its consumption is, therefore, unaccounted for : twelve years since a ton of this article would have been a large annual import, whereas it now exceeds sometimes 100 tons.

An over-dose of strychnine produces tetanus (lock-jaw) and death ; a medicinal one (one-ninth of a grain three times a day, for example) restores the sensation of paralytic limbs. The sulphate of strychnine has marked effects in doses of one-twelfth of a grain. One of Dr. Bardsley's patients, in Lancashire, who was experiencing the return of sensation in his paralysed limbs under the use of strychnine, asked if there was not something *quick* in the pills ; *quick for alive* being still in use in that part of England.

The painful interest associated with this poison has been much increased of late years by the frequency of its employment for criminal purposes ; thus rendering its detection an important process, which has been sometimes attended with uncertain results in medico-legal inquiries. Mr. W. B. Herapath, in a communication to the Royal Society, states that in one experiment he took 1-1000th part of a grain of strychnine only, and produced ten crystals of nearly equal size : of course each one, possessing distinct and decided optical properties, could not represent more than the 1-10,000th part of a grain ; in fact, it really represents much less, inasmuch as one portion of the strychnia is converted by substitution into a soluble hydriodate, and of course remains dissolved in the liquid. In this experiment diluted spirit of wine is used—one part spirit to three of water ; the smallest quantity of tincture of iodine is the re-agent, after employing heat for a short time, to set it in repose. On spontaneous evaporation or cooling, the optical crystals deposit themselves, and may be recognised by the polarising microscope.

Mr. F. Horsley, in a paper read to the British Association, maintains it to be as much out of the power of any human being to define the limits of sensibility which he has attained, as it would be to count the sands or measure the drops of the ocean. Taking 30 drops of a solution of strychnia containing half a grain, he diluted it with four drachms of water. He then dropped in six drops of a solution of bichromate of potass, when crystals immediately formed, and decomposition was complete. Splitting up the half-grain of strychnia into millions of atoms of minute crystals, he said that each of these atoms, if they could be separated, would as effectually demonstrate the chemical characteristics of strychnine as though he had operated with a pound-weight of the same.

Dr. Marshall Hall observes, that when the chemical test

fails, there remains the physiological; and he considers the effect on the most excitable of the animal species (the frog) to be at once the most delicate and specific test of this poison.

He placed one frog, fresh from the pools, in an ounce of water containing the 1-50th part of a grain of the acetate of strychnia; a second in the same quantity of water, containing the 1-66th; a third, containing 1-100th; and a fourth, containing 1-200th. All became tetanic in two or three hours, except the third, which was a female (the others being males), which required a longer time. Next was placed a male frog in 1-400th part of a grain of the acetate of strychnia dissolved in six drachms of water. In three hours and a half it became violently tetanic. In two other experiments, the 1-500th and the 1-1000th of a grain of the acetate of strychnine were detected.

Professor Kölliker, of Würzburg, has shown that—1. The Antiar is a paralyzing poison. 2. It acts, in the first instance, and with great rapidity (in five to ten minutes), upon the heart, and stops its action. 3. The consequences of this paralysis of the heart are the cessation of the voluntary reflex movements in the first and second hour after the introduction of the poison. 4. The Antiar paralyzes, in the second place, the voluntary muscles. 5. In the third place, it causes the loss of excitability of the great nervous trunks. 6. The heart and muscles of frogs poisoned with Urari may be paralyzed by Antiar. 7. From all this it may be deduced that the Antiar principally acts upon the muscular fibre, and causes paralysis of it.—*Proc. Royal Society.*

Professor Johnston maintains the bitter substance of strychnine to be so intense, that its taste can be detected in 600,000 times its weight of water.

It was long an opinion that strychnine was evanescent, and difficult, if not impossible, to detect after death; but this poison has been obtained from bony tissue long after the death and putrefaction of the victim who had been poisoned by repeated small doses of this drug. Nicotine has been more than once used with success to counteract strychnine.

THEORY OF POISONS.

Why compounds with so nearly the same elements as oxalic acid and sugar, Prussic acid and common vinegar, &c., should have such opposite effects upon the living frame, we can no more explain than we can why Ipecacuanha should excite vomiting; but we know the facts well and can turn them to very useful account. Among the substances rendered interesting by their powerful action as poisons, there are among vegetables strychnia, aconite, tobacco, Prussic acid, belladonna, &c. Among animals, there are the venom of serpents, the poison of stings, the saliva of the mad dog, &c.

The protecting power of some substances is imperfectly understood. It is, however, known to be connected with the general theory of poisons; and to this we must probably ascribe the fact that several poisons which are fatal, when applied

to a wounded surface, may be taken into the stomach with impunity.

VENOM OF SERPENTS.

Dr. J. Gilman, of St. Louis, states that the process of robbing Serpents of their Venom is easily accomplished by the aid of chloroform, a few drops of which stupefy them; and when under its influence, the poison may be taken from out of the fang; but in two days a serpent so robbed has been found as highly charged as ever with venom. Dr. Gilman inoculated several healthy vegetables with the point of a lancet well charged with the venom: next day they (the plants) were withered and dead, as though they had been scathed with lightning; so that the venom destroys all forms of organised life, vegetable as well as animal. Dr. Gilman also maintains that serpents possess the power of fascinating small animals, and that this power is identical with mesmerism.

Mr. Francis Buckland, in his deservedly popular *Curiosities of Natural History*, tells us that

The Poison of the Viper consists of a yellowish liquid secreted in a glandular structure (situated immediately below the skin on either side of the head), which is believed to represent the parotid gland of the higher animals. If a viper be made to bite something solid, so as to void its poison, the following are the appearances under the microscope: At first nothing is seen but a parcel of salts nimbly floating in the liquor, but in a very short time these saline particles shoot out into crystals of incredible tenuity and sharpness, with something like knots here and there, from which these crystals seem to proceed, so that the whole texture in a manner represents a spider's web, though infinitely finer and more minute. These spiculæ, or darts, will remain unaltered on the glass for some months. Five or six grains of this viperine poison, mixed with half an ounce of human blood, received in a warm glass, produce no visible effects, either in colour or consistence; nor do portions of this poisoned blood, mixed with acids or alkalies, exhibit any alterations. When placed on the tongue, the taste is sharp and acrid, as if the tongue had been struck with something scalding or burning; but this sensation goes off in two or three hours. There are only five cases on record of death following the bite of the viper; and it has been observed that the effects are most virulent when the poison has been received on the extremities, particularly the fingers and toes, at which parts the animal, when irritated (as it were, by an innate instinct), always takes its aim.

POISONOUS FUNGI.*

The action of Fungi is variable, some of the reputed wholesome species even proving poisonous to certain constitutions,

* Some species of Fungi contaminate the air, and render it unfit for respiration, by absorbing oxygen, and exhaling carbonic acid; in a chemical point of view, they are like animals without motion.—*Liebig*.

and the contrary. Dr. Lindley, after enjoining the utmost caution in employing Fungi, the nature of which is not perfectly ascertained, in consequence of the resemblance of the poisonous and wholesome species, adds, "but the greatest caution and knowledge will not always avail, for certain species which are in general perfectly wholesome sometimes produce very disastrous consequences. A family at Cambridge a few years since suffered from eating mushrooms; a part of what were gathered proved to be a species sold sometimes in the London markets, and ascertained by Mrs. Hussey, who has paid great attention to the subject, to be most excellent for food. The case perhaps is similar to that of the prejudicial effects sometimes experienced after eating mussels, and may be considered as a mere exception."

M. Desmartine and M. Corne, of Bordeaux, have proved that a variety of Mushroom called poisonous is not necessarily poisonous *for every locality*,—that climate and soil, in fact, modify the nature of mushrooms to an extraordinary extent. For example, the *Amanita rubra* of Lamarck is described by all authors as a violent poison; nevertheless the inhabitants of Bordeaux eat this fungus with impunity, merely roasting it on coals. Indeed, this particular kind of mushroom is a luxury in the neighbourhood of Bordeaux.

Dr. Daubeny, of Oxford, says: "Judging from the present state of our knowledge, it would rather seem as if poisonous fungi may act as ferments when introduced into the system, and thus set up a series of changes in the vital fluids which are incompatible with life.

"This will explain the circumstance, otherwise incomprehensible, *why the same fungus which operates as a poison upon one person does not affect another*; and why certain nations, as the Russians, either from national want of susceptibility or from habit, use as articles of food several kinds of mushrooms which are rejected by us as poisonous.

"They also are equally capricious in their operation, and produce effects entirely incommensurate to the minuteness of the quantity of them imbibed. It is not indeed necessary to account for this by supposing them to act as ferments; for the property of reproduction, which we must in any case ascribe to the poisonous principles which give rise to these effects, might account for the malignity of the result proceeding from a cause originally so insignificant; but at any rate, the fact is quite in harmony with the process which takes place during fermentation, where the minutest quantity introduced into a fluid susceptible of change is sufficient to operate upon the entire mass."—*Jameson's Edinburgh Philosophical Journal*.

IMPURE WATER AND CHOLERA.

Dr. Daubeny, in the paper just quoted, has observed that among the modes by which Cholera poison is disseminated, one of the most frequent perhaps is the Water used for drinking. Pure water, so far as we know, is not capable of receiving or generating the infectious principle of Cholera; but *impure* water seems to be one of the readiest means of conveying it into the system. There is a curious illustration of this fact in the comparative exemption from Cholera which was enjoyed by the parts of London supplied with pure water during the epidemic of 1849.

It appears that whilst in the district supplied with water by the Lambeth, Chelsea, and Southwark Companies the mortality was 123 in 10,000, that in the districts supplied by the New River, East London, and Kent Companies, was 48; and in those supplied by the Grand Junction and Middlesex, only 15. Now the Lambeth, Chelsea, and Southwark Companies obtained their water from the Thames, between Battersea and Waterloo Bridge; the New River, East London, and Kent Companies from the Lea and the Ravensbourne; the Grand Junction and the West Middlesex both from the Thames, but the former as high up as Kew, the latter at Barnes.

Now mark the proportion of deaths during the epidemic, in the six weeks prior to October 7, 1855. It is stated from official returns, that in the population supplied by the Southwark Company, the mortality was 85 to 10,000 inhabitants; in those which obtained their water from the Kent Company, only 19; whilst in the case of those furnished by the Lambeth Company, where the mortality in 1849 was no less than 123, it now was only 17. But this comparative exemption is accounted for by the circumstance that, whereas in 1849 this company was supplied from the river at Lambeth itself, it now (1855) draws its consumption from the Thames at Thames Ditton. No facts would seem more conclusive than these with respect to the unwholesomeness of water obtained from a river polluted with animal impurities.

It is true that Dr. Hassall, in his microscopic examination of the water supplied to London, condemns all the water-companies alike, exhibiting in his plates a formidable display of animalcules derived from every one of them.

But the presence of animalcules does not necessarily render water unwholesome; and with respect to the amount of sewage, or of dead animal matter, there can be no doubt that there must be a great difference between water brought from the Thames near London itself, and from spots several miles higher up.

Disinfection appears to be a costly process; for, during the season of 1859, the disinfectant agents poured into the sewers and sluices discharging themselves into the river were, about 4281 tons of chalk-lime, 478 tons of chloride of lime, and 56 tons of carbolic acid, at a cost of 17,733*l*.

Hippocrates.

WHAT HIPPOCRATES KNEW OF MEDICINE.

HIPPOCRATES, born at Cos, B.C. 460, was the first person who applied himself to the study of physic as the sole business of his life : hence he obtained the title of "the Father of Medicine." His family followed the pursuit of medicine for near three hundred years, and produced seven physicians, who are supposed to have written the numerous treatises which are commonly attributed to Hippocrates alone.

The principles of Hippocrates were those of rational empiricism.* He did not attempt to form his theories from *a-priori* reasoning, but from his observation of the phenomena of nature. He taught that the body is composed of four primary elements—fire, water, earth, and air ; that these elements, variously combined, produce the four cardinal humours, and these again the different organs of the body. His knowledge of anatomy was very limited, from the superstitious respect paid to the dead by the Greeks preventing the dissection of the human body. He gives such descriptions of the bones as show that he had indeed studied the subject, but not acquired any very accurate knowledge ; he does not seem to suppose that the vessels originate either in the heart or liver. Under the term "nerves," he confounds all the white tissues of the body, the nerves properly so called, the tendons, and ligaments. According to Hippocrates, the brain is glandular, and secretes the pituita, or mucus. His pathology relates principally to the investigation of the remote causes of diseases, without much speculation on their nature. However, he explains inflammation by the passage of blood into those parts which did not previously contain it. He paid great attention to the effects of change of air, warmth, moisture, food, upon its phenomena, and those of disease ; and he recommended particular attention to the constitution of the seasons.

Among the doctrines of Hippocrates is that of *Critical Days*.† He says, fevers come to their crises on the same days,

* Empiricism was the practice of physic by experience alone, discarding as unnecessary all acquaintance with the structure of the body, or reasoning on its functions.

† Dr. Cullen adopted this doctrine of Critical Days. (See *Things not generally Known*, First Series, p. 146.) But Cullen, we must recollect, was in the habit of repeating, "There must be a tub to amuse the whale."

both those which turn out fatally and those which turn out well. These days are the fourth, the seventh, the eleventh, fourteenth, seventeenth, and twentieth. The next stage is of thirty-four days, the next of forty, and the next of sixty.

Of the indications to be drawn from the examination of the pulse, Hippocrates was not aware; and the word *sphygmas* is employed by him to denote some violent pulsation only.

It is, however, upon the accuracy with which he observed the leading features of disease, and his vivid descriptions of them, that the fame of Hippocrates is principally and justly founded. Nowhere is the peculiar power of the Greeks in expressing their conceptions more strikingly shown. These marked descriptions are extracted from his *Prognostica*:

"If the appearance of the patient be different from usual, there is danger. If the nose be sharp, the eyes hollow, the temples collapsed, the ears cold and contracted, and the lobes inverted, whilst the skin of the forehead is hard, dry, and stretched, and the colour of the face pale or black or livid or leaden, unless these appearances are produced by watching or diarrhoea, or under the influence of malaria, *the patient is near death*. This description has obtained the title of *Facies Hippocratica*."

Again, how well does he recommend us to observe the position of the patient in bed. "If he lies upon his side, with the neck and arms slightly bent, and the whole body in a flexible state, since such is the position of health, it is well; but if he lies on his back, with the legs and arms extended, and still more if he keeps sinking towards the bottom of the bed, or tosses his arms and head into unusual positions, our anticipations must be most unfavourable." And, "if in acute diseases, the hands are waved before the face, as if seeking something in the air, and brushing or picking motes from the walls or bed-clothes, the prognosis must be unfavourable."

It is clear that the idea on which is founded the modern art of Auscultation (observation of disease as denoted by sound) had occurred to Hippocrates upwards of 2000 years ago. "You will know by this," says he, "that the chest contains water, and not pus, if, on applying the ear for a certain time to the side, you hear a sound like that of boiling vinegar." The non-existence of dissection prevented the following out to any sure and useful results this idea, which had occurred to the most ancient writer on physic. Accordingly, the suggestion of Hippocrates seems to have attracted no attention for many centuries. Hooke, the mathematician, not of the medical profession, and who was unacquainted with the writings of Hippocrates, said:

"There may be a possibility of discovering the internal motions and actions of bodies by the sound they make. Who knows but that, as in a watch, we may hear the beating of the balance, and the running of the wheels, and the striking of the hammers, and the grating of the teeth, and multitudes of other noises,—who knows, I say, but that it may be possible to discover the motions of the internal parts of bodies

whether animal, vegetable, or mineral, by the sounds they make? that one may discover the works performed in the several offices and shops of a man's body, and thereby discover what engine is out of order, what works are going on at several times and lie still at others, and the like? I have been able to hear very plainly the beating of a man's heart; the stopping of the lungs is easily discovered by the wheezing.*"

Hooke's prediction was realised, though not fully until the present century (1816), in the Stethoscope, or chest explorer, of Laennec; so that it took nearly two thousand years to carry out the idea of Hippocrates. His statement is in itself incorrect; but the fact of his having actually practised auscultation is no less interesting.

Hippocrates claims to have been the first to recognise the importance of Diet in the treatment of disease which had been previously neglected. In his general practice, he employed purgatives, some very violent, as the black and white hellebore and elaterium. To relieve the head in certain diseases, he used sternutatories; so that the "eye-snuff" of our day is a piece of antiquity. In acute affections, when the disease was violent, Hippocrates employed bleeding, and recommended that blood should be taken from as near the affected part as possible. This was the origin of bleeding in pleurisy from the arm on the side affected. He also made use of cupping-glasses, with and without scarification. Certain diuretic and sudorific medicines also entered into his pharmacopœia; and he was not ignorant of the virtues of the poppy.

His knowledge of anatomy and physiology, and of the processes which go on in the body during health and disease, was extremely deficient; but in the accuracy with which he observed the symptoms of disease, and in the fidelity of his descriptions, he has rarely, if ever, been surpassed. In these respects he had reached a boundary which it would have been scarcely possible to pass but by the vast body of collateral evidence which chemistry, geology, and the experimental philosophy of our times, have supplied.

Hippocrates strongly advocated the use of Cold Bathing; and Dr. Sir John Floyer, in his curious Essay, devotes an entire letter to Hippocrates' opinion "concerning the Nature of Cold Baths, and their Usefulness."

THE FIRST APOTHECARIES' HALL.

Pharmacy and chemistry are much indebted to the Arabs, who, after the fall of the Roman empire, discovered several

* From a transposition of this comparison of Hooke's may possibly have been derived the popular notion of the construction of watch-works being taken from a minute observation of the structure of the human body. The Chinese idea of a non-going watch being "dead" also favours the above association.

chemical preparations, and introduced several new medicines, still employed by physicians. They established in the eighth century the first public Apothecaries' Hall in Bagdad. We owe also to the Arabs the first legal dispensaries, in the ninth century. Whilst chemistry and pharmacy were cultivated industriously in the East, Europe was plunged in darkness and ignorance; when, at length, a new light was kindled by Constantine of Carthage, who established the first regular pharmacy in Europe, namely, in Salerno. He called these establishments *stationes*, and the dispensing chemists *confectionarii*.

MEDICAL RINGS.

From very early classic times we read that doctors wore rings. Many, but not all, of these were supposed to possess hygienic properties, resident either in the metallic hoop, or the stone set in it, or else in some nostrum enclosed in the bezil. Hippocrates considered a ring as necessary to complete the toilet of the man of medicine, and it was probably supposed to be curative in its effects. Antoninus Musa, the physician of Augustus, used to wear a handsome gold ring which the Emperor had given him for bringing him safely through a dangerous malady; and in further acknowledgment of his services, Augustus ceded to the Roman doctorate, through him, the *jus annuli*, or power of wearing the ring, with all its privileges.

There were two varieties of the *annulus medicus*, or ring medical—the one used for surgical operations, the other adopted by physicians. The surgical practitioner, with his cuffs turned up, and showing nothing on his hands but a costly ring, could approach without difficulty, and lay them lightly on the skin of the most timid patient; and then gently exploring his way, could press a spring against a lancet or *bistouri caché*, which, darting forth, swift and pungent as a hornet's sting, into the vein, abscess, or artery he might design to open, was as instantly retracted; and while the sufferer was indulging in expressions of indignant surprise, the operator was holding a basin under the wound, and patting the excited martyr on the back, congratulating him on his admirable courage and stoic indifference to pain.

The rings of physicians, though the functions assigned to them were more diversified, produced no such strikingly efficacious effects as those of their chirurgical brethren; still they enjoyed a wide vogue, and were confidently prescribed to the sick in a great variety of maladies. Plain iron hoops, especially when scored with cabalistic tracteries, worked, it was affirmed, wonderful cures. Alexander Trallianus speaks with great assurance of an iron ring of his own devising, which was invaluable in hypochondriasis from hepatic derangements,

and generally for dyspeptics, disorders which we now often vainly seek to exorcise with blue-pill. It was no doubt the known magnetic capabilities of iron which first recommended rings of this metal in the treatment of diseases, and led the physicians to employ iron rings magnetised, as we do, in hemi-erania and brow-agues.

The stones set in rings were supposed to exercise a still greater control over diseases than even the iron hoop, albeit well magnetised and impressed with mysterious characters or symbols. Thus, a dangerous hemorrhage, which neither sedatives, nor absorbents, nor yet astringents, could control, would cease (on the homœopathic principle of *similia similibus*) as soon as the patient put on a blood-red cornelian ring: coral, which, in a ring, the ancients prized much more than the moderns, was, on the authority of Metrodorus and Zoroaster, an infallible remedy for, as well as antidote against, nervousness and causeless fears; wine-coloured amethysts protected their wearers from intoxication, and all its pathological consequences; hyacinths secured sleep as infallibly as opium; agates stood high in the esteem of most mineralogist doctors for the cure of the blindness *amaurosis*, or *gutta serena*; * and jaspers enjoyed great fame for their powers of discussing drop-sies and driving away fevers.—*Abridged from Fraser's Magazine*, 1856.

THE HEALING ART.

Two centuries ago, the qualifications for the practice of the healing art are shown by the clumsiness and cruelty with which operations were then performed; so that we must not feel surprise at the low state of medicine and surgery. Sir William Petty informs us that, even in his time, the proportion of deaths to cures in the Hospitals of St. Bartholomew and St. Thomas was 1 to 7; during 1741 the mortality had diminished to 1 in 10; during 1780, to 1 in 14; during 1813, to 1 in 16; and in 1827, out of 12,494 patients under treatment, only 259 died, or 1 in 48. The Duke of Sussex justly said, in one of his addresses as President of the Royal Society: "Such is the advantage which has already been derived from the improvement of medical science, that, comparing the value of life, as it is now calculated, to what it was a hundred years ago, it has absolutely doubled." And Sir Astley Cooper asserted that the human frame was better understood in his time by students than it had previously been by professors.

* Milton, in the celebrated complaint on his Blindness, says:

"So thick a *drop serena* hath quench'd their orbs,
Or dim *suffusion* veiled."

Paradise Lost, b. iii.

Physiological Chemistry.

MATERIALS OF A MAN.

DR. LANKESTER has demonstrated the elementary composition of the human body, and exhibited in the lecture-room the absolute quantities of the elements contained in it, with the exception of four—oxygen, hydrogen, nitrogen, and *fluorine*. The three first could not be exhibited on account of their bulk; the last on account of its rarity.

A human body weighing 154 lbs. was stated to contain 111 lbs. of oxygen gas, which would occupy about 750 cubic feet; and 14 lbs. of hydrogen gas, which would occupy nearly 3000 cubic feet of space: the nitrogen gas would occupy about 20 cubic feet. Amongst the other elements there were 21 lbs. of carbon, $1\frac{1}{4}$ lbs. of phosphorus, 2 lbs. of the metal calcium, 1 oz. of sodium, 100 grains of iron, 150 grains of potassium, 10 grains of magnesium, and 1 grain of silicon.

These elements, when mixed together as they are in the human body, were represented by 111 lbs. of water, 15 lbs. of gelatine, 12 lbs. of fat, 8 lbs. of fibrine and albumen, 7 lbs. of phosphate of lime, and a variety of other salts. It was shown that these substances are supplied to man through the agency of plants, and that it is in the tissues of plants that the great chemical changes go on which convert the inorganic elements into organic substances, fitted for the food of man and animals.

HEAT OF MUSCULAR CONTRACTION.

Professor Matteucci, in a letter to Mr. Faraday, mentions some new studies on *induced contraction*, or the phenomenon of the irritation of a nerve in contact with a muscle in contraction. Experiments made on the discharge of the torpedo led Matteucci to establish the existence of an electrical discharge in the act of muscular contraction. The general conclusion to be drawn from these researches is, therefore, that the chemical action which accompanies muscular contraction develops in living bodies, as in the pile, or in a steam-engine, eat, electricity, and *vis viva*, according to the same mechanical laws.

ANIMAL HEAT.

There is no question amongst either chemists or physiologists in regard to the general fact, that the main source of Animal Heat is the oxygenation (by a kind of combustive process) of the hydro-carbons contained in the food. Now all these hydro-carbons, such as starch, sugar, oil, &c., are either directly or indirectly derived from the vegetable kingdom; and not only a certain amount of oxygen, hydrogen, and carbon has been consumed in their production, but also a certain amount of solar light and heat, which they may thus be said to embody. The combustive process is not so carried out in the living body as to give forth light, save in a few exceptional cases; but it reproduces in the form of heat all that was embodied in the respiratory food; and thus the warm-blooded animal may be said to be continually restoring to the universe that force which the growing plant had appropriated to itself. And, carrying the principle a little further, we may say, that in utilising the stores of coal which have been prepared by the luxuriant vegetation of past ages, man is not only restoring to the atmosphere the carbonic acid and water of the carboniferous epoch, but is actually reproducing and applying to his own uses the light and heat which its vegetation drew from the solar beams, as if for the very purpose of fixing them until he should find the means of turning them to account.

Looking at this matter from the stand-point afforded by the "correlation" doctrine, we are led to question whether the project of the Laputan sage to extract sunbeams from cucumbers was so very chimerical after all; while we cannot but feel an increased admiration of the intuitive sagacity of that remarkable man George Stephenson, who was often laughed at for propounding, in a somewhat crude form, the very idea which we have just been endeavouring to present under a more philosophical form.*—*National Review*, No. 8.

BURNING AND UNBURNING OF THE HUMAN BODY.

Wonderful is it to reflect that every animal exists at first as a minute speck of matter called a germ or ovum, of simplest form, but in which all the vital powers are already present, under

* It is believed to have been first remarked by George Stephenson, that the original source of the power of heat engines is the sun, whose beams furnish the energy that enables vegetables to decompose carbonic acid, and so to form a store of carbon and of it combustible compounds, afterwards used as fuel. The combination of that fuel with oxygen in furnaces produces the state of heat, which being communicated to some fluid, such as water, causes it to exert an augmented pressure, and occupy an increased volume; and these changes are made available for the driving of mechanism.—Prof. Rankine's *Manual of the Steam-Engine*, 1859.

the influence of which new matter begins quickly to be selected and taken in from around to form the compound fluid called *blood*; and out of this blood afterwards are gradually built up all the parts and organs of bone, muscle, skin, hair, eye, ear, &c. which the body in its most perfect state possesses; and not only are the parts so built up to full size and strength during the years of growth, but they are receiving constant support and repair (as a ship's crew may be preserved vigorous for 100 years by the constant exchanging of old men for young), through the long period of middle age and gradual decline; and, most wonderful of all, during the middle term of its existence the body is able to throw off germs such as it was originally itself, to continue the race through future ages.—*Arnott.*

Chemically, the human organism is the continual subject of swift changes of its composition in opposite directions; and these changes have been eloquently termed by Dr. George Wilson, "the Burning and Unburning of the Human Body."

There is continual addition of matter to the body, and continual withdrawal of matter from it; but apart from this, and within the ring-fence of its own organism, a process of combustion and one the very reverse are going on together. Here one tissue is burning like fuel, and there another is becoming the depository of combustible matter. We have as it were millions of microscopic wind-furnaces, converting into carbonic-acid gas, water-vapour, and other products of combustion, all the combustible elements of the body; and millions of blast-furnaces reducing the starch and sugar of the food, and the sulphates and phosphates of the body, into inflammable oils and other fuels, which are finally transferred to the wind-furnaces, and burned there. *Burning*, and what we must call in contradistinction *unburning*, thus proceed together; the flame of life, like a blowpipe-flame, exhibiting an oxidising and a reducing action at points not far distant from each other.

CIRCULATION OF MAN AND THE WHALE COMPARED.

Those who have not considered the subject must be surprised at the quantity of blood which is propelled through the heart of any moderately-sized animal in the course of twenty-four hours. In man the quantity of blood existing in the body at any given moment is probably from thirty to forty pints. Of these an ounce and a half, or about three tablespoonfuls, are sent out at every stroke, which, multiplied into seventy-five (the average rate of the pulse), gives 1125 ounces, or seven pints in a minute; *i. e.* 429 pints, or nearly 54 gallons in an hour, and 1260 gallons, *i. e.* nearly twenty-four hogsheads, in a day. Now, if we recollect that the whale is said to send out from

his heart at each stroke fifteen gallons, the imagination is overwhelmed with the aggregate of the quantity that must pass through the heart of that Leviathan of the deep in twenty-four hours. It is a general law that the pulse of the larger animals is slower than that of the smaller; but even if we put the pulse of the whale as low as twenty in a minute, the quantity circulated through the heart, calculated at fifteen gallons for each pulsation, will be 432,000 gallons, nearly equal to 7000 hogsheads, in twenty-four hours.

The consideration of this amazing quantity is, however, a subject of mere empty wonder, if not accompanied with the reflection that, in order to produce the aggregate amount, the heart is kept in constant motion; and that, in fact, it is incessantly beating, as it is termed, or throwing out the blood in the arteries, from the first period of our existence to the moment of our death, without any sensation of fatigue or even without our being conscious of the process, except it be interrupted by corporeal or mental agitation.

TRANSFUSION OF BLOOD.

In November 1667, the remarkable experiment of Transfusing the Blood of a sheep into a man was performed for the first time in England before the Royal Society, at Arundel House, Strand. The subject was a poor student named Arthur Coga, who offered himself for a guinea, which was accepted. The experiment was performed chiefly by Dr. King, in his arm, with such dexterity and ease that Coga did not wince or make the least complaint, and "found himself very well upon it." After the operation, he drank a glass or two of canary, and took a pipe of tobacco, in the presence of forty or more persons. He then went home, and continued well. "The experiment was repeated in about three weeks, when eight ounces of blood were taken from Coga, and about fourteen ounces of sheep's blood injected with equal success. This gave rise to the notion that by transfusion might be realised the alchemical reveries of an *elixir of life and immortality*. Some experiments of transfusion were next made upon the Continent; but at length a lunatic in Paris died under the second operation, which led to the immediate abolition of the process.

This very interesting inquiry has, however, been resumed by the physiologists of the present age, with the many aids of the advanced state of science. Thus, recently Dr. Brown-Séquard has presented to the French Academy of Sciences a paper, in which he endeavours to prove the two following propositions:

1st. That arterial or venous blood, from an animal of any one of the four classes vertebrata, containing oxygen in sufficient quantity to be

scarlet, may be injected without danger into the veins of a vertebrated animal of any one of the four classes, provided that the amount of injected blood be not too considerable. 2d. Arterial or venous blood of any vertebrated animal, being sufficiently rich in carbonic acid to be almost black (*noirâtre*), cannot be injected in the veins of a warm-blooded animal without producing phenomena of asphyxia, and most frequently death, after violent convulsions, provided that the quantity of injected blood be not below one five-hundredth weight of the animal, and also that the injection be made not too slowly.

Dr. Brown-Séquard states that he has transfused into the jugular vein of dogs, without any ill effect, blood of rabbits, guinea-pigs, cats, cocks, hens, pigeons, ducks, turtles, and tortoises, frogs, and eels. In rabbits and birds he has also transfused blood of other animals without any marked bad effect. He attributes chiefly to carbonic acid the phenomena which had been considered as due to differences in the blood of various species.

In many communications to the Société de Biologie, the same physiologist has related facts to prove that in the experiments of Blundell, of Dieffenbach, and of Prevost and Dumas, there were many causes of failure unknown to these experimenters which have prevented them from reëstablishing life permanently in dogs bled to death, and transfused with blood from animals of another species. These causes of failure were—1st, that too much blood was transfused at once; 2d, that the blood was not fresh; 3d, that it did not contain oxygen enough, and contained too much carbonic acid.

Dr. Brown-Séquard has ascertained that even the blood of birds, defibrinated and rich in oxygen, has been able to re-establish full and durable life in dogs weighing from 15lbs. to 20lbs., and having lost more than 16 ozs. of arterial blood, *i. e.* more blood than the dogs of Blundell had lost. From 30 to 48 grammes of bird's blood (1 oz. to 1½ oz.) have been sufficient in many cases to restore full life.

IRON IN THE BLOOD.

Among the organismal metals, Iron is *par excellence* the metal, as certainly it is by the testimony of ages, industrially the most excellent of them all. All countries have honoured the smith; and he would wonder more than he does at his own skill, if he realised that the iron which he hammers is hammered not merely by iron in his hand, but also by iron in his blood. Yet the function of this iron is so little known that, though statisticians have calculated how many railways might be made out of the blood-iron of a generation of mankind, the most acute and accomplished chemists tell us, to take the words of one, that “we are unfortunately perfectly ignorant regard-

ing the special uses of iron in the animal economy." And we have to turn to a poet to find the reason why it is so useful. Alfred Tennyson, in his *Princess*, makes the father of his heroine exclaim, when his stately daughter shows no signs of relenting towards the wounded prince,

"I've heard that there is iron in the blood,
And I believe it."

Except nickel and cobalt, iron is the only decidedly magnetic metal; and it is more magnetic than they. It must influence the body in virtue of its magnetism in a way no non-magnetic metal could, and its magnetic condition must be continually altering. The patients of Reichenbach may sometimes have deceived themselves or him, or both, when they declared that their sensations were different according as they lay along or across the magnetic meridian; but it is certain that the iron in our bodies must be in a different magnetic condition in the opposite positions, and it is reasonable to suppose that some persons may be sensitive enough to appreciate the difference. At all events, the observations of Faraday on the magnetic condition of flesh and of living animals demonstrate that the *organismal iron is magnetically active*. We know also that magnetism cannot be developed without a simultaneous development of electricity; so that magnetic changes in the ferruginous blood and flesh must be accompanied by electrical changes. Electricity also invariably develops magnetism, and we know that electrical currents are constantly traversing the muscles and other organs. Such currents will react on the magnetic masses in their neighbourhood, and be reacted on by them, with a corresponding exaltation of the intensity alike of the electricity and the magnetism. Further, the peculiar force or polarity which acts along the nerves resembles in many respects electrical and magnetic force. It is probable that all three forces or polarities powerfully influence each other, and that the magnetisable iron of the body is continually taking part in such reciprocal actions. If, moreover, the iron in the blood-vessels, as has been suggested, becomes magnetic oxide at each half-revolution of the blood, it will be much more magnetic at each of the great crises of the circulation than at any other period.—*Dr. G. Wilson; Edinburgh Essays, 1856.*

SERVICES OF PHOSPHORUS TO THE HUMAN BODY.

The importance of Phosphorus to the human organism is shown by its invariable presence in it: as in the hardest bone and the most pulpy nerve; in one form, or rather series of forms, in the blood, in another series in the flesh-juices, in a third in

the milk, in a fourth in the brain, and probably in other modifications elsewhere in the organism, and associated with all its critical changes.

Limiting our attentions to the well-known modifications of phosphoric acid, we may sketch in outline how they may render service to the body.

A child is beginning to walk, and the bones of its limbs must be strengthened and hardened. Phosphoric acid accordingly carries with it three units of lime to them, and renders them solid and firm. But the bones of its skull must remain comparatively soft and yielding, for it has many a fall; and the more elastic those bones are, the less will it suffer when its head strikes a hard object, so that in them we may suppose the phosphoric acid to retain but two units of lime, and to form a softer, less consistent solid. And the cartilages of the ribs must be still more supple and elastic, so that in them the phosphoric acid may be supposed to be combined with but one unit of base, as the uncrystalline, gelatinous metaphosphate.* On the other hand, its teeth must be harder than its hardest bones, and a new demand is made on the lime-phosphates to associate themselves with other lime-salts (especially fluoride of calcium), to form the cutting edges and grinding faces of the incisors and molars. All the while also the blood must be kept alkaline, that oxidation of the tissues may be promoted and albumen retained in solution; and yet it must not be too alkaline, or tissues and albumen will both be destroyed, and the carbonic acid developed at the systemic capillaries will not be exchanged for oxygen, when the blood is exposed to that gas at the lungs. So phosphoric acid provides a salt containing two units of soda and one of water, which is sufficiently alkaline to promote oxidation, dissolve albumen, and absorb carbonic acid; and yet holds the latter so loosely, that it instantly exchanges it for oxygen, when it encounters that gas in the pulmonary capillaries. Again, the flesh-juice must be kept acid (perhaps, as suggested, in electro-polar opposition to the alkalinity of the blood, as affecting the transmission of the electrical currents which are now known to traverse the tissues); and phosphoric acid provides a salt, containing two units of water and one of potash, which secures the requisite acidity. Further, in some of the serous and other liquids of the body, a changeable salt is required; and for this phosphoric acid provides, by com-

* Von Bibra has made the beautiful observation that those bones which are the most exposed to mechanical influences contain the largest quantity of earthy constituents (chiefly phosphate of lime). The action of this law is manifested even in different families of the same class of animals; thus, for instance, in the rascors or scraping birds, the femur contains the largest quantity of phosphate of lime; in the gallatores, or waders, the tibia; and in all other birds the humerus.—*Lehmann's Physiological Chemistry, Cavendish Soc. Trans.* vol. i.

binning with soda, ammonia, and water, to produce microcosmic salt, which is alkaline in its integrity, but by parting with the easily-lost volatile ammonia becomes alkaline.*

FORMATION OF BONE.

Dr. Roget has justly and beautifully said that, as sculptors, before working upon the marble, first execute a model of a coarser and more plastic material, so the first business of the arteries is to prepare a model of the future bone, constructed, not with the same material of which it is afterwards to consist, but with another of a simpler and softer nature, namely cartilage. In proportion as the fabric is enlarged, the necessity for mechanical support increases, and stronger provision must be made for resistance to external violence. The removal of the cartilage may be compared to the taking down of the scaffolding which had been erected for the intended building. But this scaffolding is not taken down at once; each part is carried away piece by piece, as the operation of fixing in their position the beams and pillars of the edifice proceeds. The way is cleared at first by the absorption of the central part of the cartilage, and a few particles of ossific matter are deposited in its room. The arteries then enlarge, and deposit granules of calcareous phosphate, which are laid down, particle by particle, in regular lines, so as to form continuous fibres, which being crossed and connected, unite from different centres, not indiscriminately, but by definite laws. Each distinct bone is formed from a certain number of ossific centres, which unite as if by a natural affinity appertaining to that bone only, and not extending to the adjacent bones.

* Dr. George Wilson (*Edinburgh Essays*, 1856), from whose striking paper on "Chemical Final Causes" the above is quoted,—from his own results, and those of others in the course of agricultural analyses of bone-earth, cannot avoid inferring that several phosphates of lime exist in bones, although in the ash of the latter the nature of these salts, as they occurred in the living organism, cannot be ascertained. Dr. Wilson has accordingly felt at liberty to assume as possible the phosphates referred to in the text as existing in the child's skull and ribs.

At all periods, moreover, in the life of the body, the liquid albumen and fibrin of the blood are becoming solid albumen and fibrin in the tissues. Both are becoming, in the nursing mother, the casein of her milk, and that casein in her suckling's body is becoming the albumen and fibrin of its flesh and blood, and building up its organs in other ways.

Each of these blood-forming, flesh-forming, milk-forming, tissue-forming bodies, albumen, fibrin, and casein, and likewise their analogue gelatine, are inseparably accompanied by all their liquefactions, solidifications, and transmutations, by phosphates, which, in virtue of their mobility, are able to liquefy, solidify, and undergo transmutation as the body which they accompany does. We cannot pretend to follow these changes step by step, for they occur within the inaccessible penetralia of a living structure; but certain it is that the phosphates accommodate themselves to changes which no other salts we know could submit to.

THE USE OF SALIVA.

Dr. Bence Jones considers "the action of Saliva upon the starch we take as food is similar to that of a ferment, and causes it to undergo a change into sugar. If you take a portion of pure starch, and hold it in the mouth for only two minutes, you can obtain distinct and decided traces of sugar. If you take a solution of starch not treated with saliva, and employ the test for sugar (sulphate of copper and liquor potassæ), you have no reduction of the oxide of copper; but in the other mixture of starch and water, which has been held in the mouth for two minutes only, you may see distinctly a beautiful red line of reduced copper, the evidence of the presence of sugar. If the starch is left in the mouth for three minutes, a still more manifest action is apparent; and if it remains there five minutes, there is a distinct mass of reduced copper, which is proportioned to the quantity of sugar formed out of the starch."

THE DIGESTIVE PROCESS.

The solution of the food by the gastric juice is a chemical operation, and the gastric juice is a chemical agent, the exact nature of which is clearly ascertained. Spallanzani discovered this juice to be of an acid nature, and Dr. Prout proved this acid to be the muriatic. If meat and gastric juice be enclosed in a glass tube, and kept at the temperature of the human body, a product is obtained closely resembling the fluid formed by the solution of the food in the stomach. If meat be enclosed in a glass tube with dilute muriatic acid, and kept at the temperature of the blood, a perfectly similar product is obtained.

The muriatic acid constituting the essential ingredient of the gastric juice is conceived to be derived by an act of secretion from common salt (muriate of soda), contained in the blood. The alkali, the base of the salt, is retained in the blood to maintain the alkaline condition essential to its healthy constitution; while the acid is liberated, and poured, in the form of gastric juice, into the stomach, to accomplish the solution of the food.

A remarkable opportunity of observing the process of digestion actually in progress in the human stomach presented itself, many years since, to Dr. Beaumont, of the United States, by examining and experimenting upon one St. Martin, a Canadian, with an orifice in his stomach, occasioned by a gun-shot wound at an early period of his life, and which never healed, although the surrounding parts cicatrised readily.

Dr. Beaumont found the inner coat of the stomach to be of a light or pale pink colour, varying in its hues according as it

was full or empty. It had a soft or velvet-like appearance, and was constantly covered with a thin, transparent, viscid mucus, secreted from small oval-shaped glandular bodies beneath the mucous coat. When aliment or other irritants were applied to the inner coat of the stomach, there were seen, with a magnifying-glass, innumerable minute lucid points, and very fine nervous and vascular papillæ arising from the villosous membrane, and protruding through the mucous coat, and from which distilled a pure, limpid, colourless, and slightly viscid fluid. This fluid is always distinctly acid, and is the gastric juice which converts the food into chyme. Dr. Beaumont regards, with much probability, the sensation of hunger as occasioned by a distension or repletion of the gastric vessels, which cannot discharge their contents till the stomach is irritated with food. When the food was placed in the gastric juice taken out of the stomach, the same chemical result was obtained, it being kept at the temperature of 100° Fahrenheit, which Dr. Beaumont found to be that of the stomach. This artificial digestion, however, occupied a period two or three times longer than when the gastric juice acted upon the same materials in the stomach.

Dr. Beaumont has published the times in which various articles of food are digested. A full meal of various articles of food was digested in from three hours to three hours and a half; but when the stomach was diseased, or affected by narcotics, or when the mind was agitated by anger, or other strong emotions, or when the food was taken in large masses, the time of digestion was prolonged; while, on the contrary, it was shortened when the food had been minutely divided and mingled with saliva, and when the temperature of the stomach was raised. The following is the time required for the chymification of various food, as determined by Dr. Beaumont:

	H. M.		H. M.
Venison-steak, broiled . . .	1 35	Eggs, fresh, hard boiled	
Sucking-pig, roasted . . .	2 30	or fried	3 30
Lamb, fresh, boiled . . .	2 30	Trout (salmon), fresh, boiled	
Beef-steak, boiled . . .	3 0	ed	1 30
Mutton, fresh, boiled . . .	3 0	Cod-fish, cured, dry, boiled	2 0
Pork-steak, boiled . . .	3 15	Flounders, fresh, fried . .	3 30
Veal, fresh, boiled . . .	4 0	Salmon, salted, boiled . .	4 0
Beef, old, hard, salted, boiled	4 15	Oysters, fresh, raw . . .	2 55
Tripe, soused, boiled . . .	1 0	Oysters, fresh, roasted . .	3 15
Brains, animal, boiled . . .	1 45	Oysters, fresh, stewed . .	3 30
Liver of the ox, fresh, boiled	2 0	Oyster-soup	3 30
Eggs, whipped, raw . . .	1 30	Butter, melted	3 30
Eggs, fresh, raw . . .	2 0	Mutton-suet, boiled . . .	4 30
Eggs, fresh, roasted . . .	2 15	Beef-suet, fresh, boiled . .	5 50
Eggs, fresh, soft boiled or		Cheese, old, strong, raw	3 30
fried	3 0	Calf's-foot jelly, boiled	1 0

	H. M.		H. M.
Isinglass jelly, boiled	1 0	Fowls, boiled or roasted	4 0
Gelatine, boiled	2 30	Duck, roasted	4 0
Tendon, boiled	5 50	Rice, boiled	1 0
Turkey, boiled	2 25	Cake, sponge	2 30
Turkey, roasted	2 30	Custard, boiled	2 45
Geese, wild, roasted	2 30	Dumpling, apple, boiled	3 0
Chicken, full-grown, fricas- seed	2 45	Bread, wheat, new	3 30

St. Martin was still living, in 1858, when Dr. F. S. Smith, of Pennsylvania College, made certain experiments with a view of settling some undetermined questions relating to the physiological action of the stomach, particularly that of the nature of the acid contained in the gastric juice; the analyses being made upon the fluids obtained from the Canadian's stomach while digestion was in progress.

In every instance, and with all kinds of food employed, the reaction of the fluid of digestion was distinctly *acid* to litmus-paper; while that of the *empty* stomach (as shown by the introduction of test-papers through the orifice), and of the fluid obtained by mechanical irritation, was as distinctly *neutral*. The *temperature* of the stomach while digestion was in progress was about 100° Fahrenheit; when empty, about 98°. The general conclusions, from a number of experiments, are:

1. That the secretions of the stomach, when digesting, are invariably acid. 2. That the acid reaction was not due to the presence of phosphoric acid. 3. That if hydrochloric (muriatic) acid was present, it was in very small quantities. 4. That the main agent in producing the characteristic reaction was *lactic acid*.

Dr. Harley, in a paper read to the British Association at Leeds in 1858, considers that the gastric juice does not destroy the power possessed by the saliva of transforming starch into sugar; consequently the digestion of amylaceous food is continued in the stomach. The gastric juice has also the property of changing cane into grape sugar.

From experiments it has been found that the gastric juice is prevented from digesting the living stomach by the coating of mucus which covers its walls. Wherever this mucus is absent, the gastric juice attacks the walls of the living stomach, and dissolves them, causing perforations and death. As regards the bile, it seems that this secretion takes an active part in rendering the fatty matters of our food capable of being absorbed into the system.

The most curious of all the digestive fluids, however, is the *pancreatic secretion*, for it unites in itself the properties of all the others. It not only transforms starch and other substances into sugar, but it emulsions fat and even digests protein compounds. As a remedy in indigestion, *pancreatine* should be

greatly superior to *pepsin*, which can only digest one kind of food, namely protein. With pancreatine we should be able to digest any kind of food; and when obtained in a state of purity, it must prove an invaluable boon to suffering humanity.

When *pepsin* is introduced into the stomach, at the time of taking food, the operations of nature will be facilitated.* Now *pepsin* has been prepared from the rennet-bags used in making cheese. It is a syrupy solution, which, being mixed with starch and dried, forms a grayish powder, and is either used by itself or mixed with reagents which do not affect its digestive properties. Thus prepared, *pepsin* can be taken either in water or between slices of bread; and according to Dr. Ballard, who has introduced it into London practice, it is capable of replenishing the gastric juice of the human body. Among the cases recorded by Dr. Ballard is that of a lady, sixty-six years of age, who for four years had suffered great pain for three or four hours after every meal. The natural consequences were excessive prostration and complete disgust for food; and she had for many weeks limited herself to four rusks and a little milk and beef-tea per diem. The first day *pepsin* was used she ate and enjoyed a mutton-chop; in a few days she ate freely, and gradually improved; and at length was able to give up the *pepsin* entirely, to eat without pain, and to walk some miles without fatigue.

THE LAW OF MORTALITY.

If we relied upon our reason alone (says Mr. A. Smee), we should be led to suppose that a mechanism which had the power of self-repair, and which had the power of self-feeding, would last for ever; for we should fail to perceive by what means it could possibly stop. With respect to the mechanism of animals, including man himself, of the largest communities, one after another succumbs to death; for of children born certainly not more than one in ten thousand lives to a hundred; and of those who attain to the advanced age of a century, as certainly not more than one in twenty thousand has his life prolonged to 150: consequently, not more than one child out of twenty millions lives to the latter age.

By Gompertz's law of mortality, the sum of all the people who have as yet lived upon the earth, does not warrant the expectation of an individual attaining the greatest age which history actually reveals as having been reached; hence mathematical reasoning upon increasing numbers might lead us to infer that man is really immortal, and death but accidental. To medical science, however, death appears as inevitable as growth; and as the child is developed from the boy and grows

* Liebig maintains that *pepsin* is nothing more than a portion of mucous membrane, or of gluten, in a state of decomposition.

to the man, so the man in his turn as certainly retrogrades to senility and death. We may assume that we are born with the seeds of death, and that death is as natural to man as his growth and development. I have watched with intensity of feeling my aged patients passing without disease from manhood to death; and whilst, as the result of my observations, it is merely accidental whether the retrogression takes place more rapidly in one organ than another, it is clear that death itself is not an accidental, but a normal result, neither to be averted by medicine nor parried by the mode of life. Viewing age in this light, the physician must not expect much from his skill, when he attempts to ward off a result which we are designed from birth to suffer. Nevertheless, health may be secured and life prolonged by care and the strictest attention to physical laws.

The conditions of health should be rigorously followed. All external agencies, especially heat, should be duly regulated, and the diet should be most carefully adjusted to the power of digestion and the requisite amount of food. When age, unaccompanied with disease, sets in, the appetite gradually and increasingly fails, nutrition and assimilation gradually lessen; and the capacity to generate force and heat diminishes. At last, nervous power fails, and the patient silently passes into the sleep of death. To this end is man born, and must submit; for as sure as the endogenous tree grows itself to death, so does man, by virtue of some changes in his organisation, cease to evince the powers of health, and finally of life.—*Smee on General Debility and Defective Nutrition.*

VELUTI IN AQUARIUM.

The wonderful cycle of organic life in which the constituents of the atmosphere are made to pass through one living body after another, and are at last restored to it in their pristine state, is conveniently presented to the observation of every one in the Aquaria, now the fashionable ornaments of our drawing-rooms.

Every self-sustaining Aquarium ought to include three kinds of living beings, namely, plants, vegetable-feeding animals, and carnivorous animals. Thus, in a fresh-water tank we may have vallisneria, water-snails, and gold-fish; in a marine tank, some of the grass-green sea-weeds, anemonies, phytophagous gasteropods, and blennies or gobies. The plants will thrive in sunlight on the carbonic acid and ammonia diffused through the water; invisible diatoms too will increase and multiply at the expense of the same materials; the anemonies and the mollusks will support themselves on the vegetable diet thus prepared for them; their eggs and young serve to sustain the predaceous fish; and while the plants are continually imparting fresh oxy-

gen to the atmosphere of the tank, this is as constantly consumed by the animal inhabitants, which are restoring to the water during their whole lives the carbonic acid and ammonia of which the plants deprived it.—*National Review*, No. 8.

THE SOIL, THE PLANT, AND THE ANIMAL.

How much stronger at every step becomes the likeness between the Soil, the Plant, and the Animal! how much closer their connection! how much more indissoluble the union that binds them together!

When dry bone is burned, the ash that remains behind amounts to two-thirds of its weight, and consists almost entirely of phosphates of lime and magnesia, which are so abundantly present in the ash of different varieties of grain. This *bone-earth*, as it is called, must exist in the soil. The plant draws it from the earth by its roots. The cow eats it with the herbage she crops from the fields, and parts with it again in the milk she produces to feed her young.* The calf sucks the milk, and works up the phosphates it contains into the form of living bones, adding daily to their size and weight. Without bone our present races could not exist. It forms the skeleton to which the softer parts are attached, and by which they are supported; but the life of the animal being at an end, the function of the bone as a living thing is discharged. It falls to the earth, and new plants take up its phosphates again, to send them forward on a new mission into the stomachs of other living and growing animals. How beautiful is all this! —*North British Review*, No. 6.

THE ANIMAL AND VEGETABLE COMPARED.

The dependence of the Animal and Vegetable kingdoms one upon the other, as well as their antagonism, may be seen at a glance by the following diagram, given in Dumas and Boussingault's work on *Organic Nature*:

AN ANIMAL is an apparatus of COMBUSTION.	A VEGETABLE is an apparatus of REDUCTION.
<i>Burns</i> Carbon, Hydrogen, Ammonium.	<i>Reduces</i> Carbon, Hydrogen, Ammonium.
<i>Exhales</i> Carbonic Acid, Water, Oxide of Ammonium, Azote.	<i>Fixes</i> Carbonic Acid, Water, Oxide of Ammonium, Azote.

* A single milch cow removes from the soil every year in its milk and annual calf what is equivalent to fifty pounds of bone-dust. This must, after a time, affect the herbage, and through it the milk of the cow and the growth of the calf. To add bone to the calf, therefore, bone-dust must be added. How curious is this!

Consumes Oxygen,
Protein,
Fats,
Starch,
Sugar,
Gum.

Produces Heat,
Electricity.

Restores its elements to the air or earth.

Transforms organised matters into mineral matters.

Produces Oxygen,
Protein,
Fats,
Starch,
Sugar,
Gum.

Absorbs Heat.
Abstracts Electricity.

Derives its elements from the air or from the earth.

Transforms mineral matters into organic matters.

LIFE OF THE PLANT AND THE ANIMAL.

Vegetable food contains a large proportion of starch or gum, while in the body of the Animal these substances are wholly wanting. What becomes of the starch when eaten? Why does it exist so abundantly in plants? What purpose does it serve in the animal economy? Again, all animals breathe. They inhale atmospheric air, containing one two-thousand-five-hundredth part of carbonic acid; and they exhale an air containing from one to four or five hundredth parts of the same gas. In other words, the living animal is constantly discharging carbon into the air, in the form of carbonic acid. Whence is this carbon derived? What part of the food supplies it?

The starch and sugar of the food supply the carbon for respiration. The leaves of plants take in carbon from the air in the form of carbonic acid, that it may be converted into starch and other analogous compounds of which their substance consists. The digestive organs of animals undo the work of the leaves, and their lungs return the same carbon to the air, in the same gaseous form of carbonic acid. That which enters the stomach in the form of starch escapes from the lungs in the form of carbonic acid and watery vapour. Thus, in another way, are animal and vegetable life connected, and again they play as it were into each other's hands. And it is beautiful to consider, that while the plant and the animal appear thus to be working contrary to each other, they are in reality producing each what is necessary to the existence of the other, and perform each its allotted part in maintaining the existing balance or stability of things. The round of animal and vegetable life may be regarded as a little episode in the history of nature. The system of the inanimate universe is complete of itself. The dead matter of the globe is comparatively little affected by the existence of life. A small portion of it is, for a time, worked up into vegetable and animal forms, and then returns again to the earth as it was. But what a beauty,

though transient, does this poetry of life impart to the face of nature, clothing it with verdure, and peopling it with moving and graceful forms! What a broad field has it afforded for the exercise of the Creator's skill and bounty! Again, all the four classes of substances contained in vegetables appear equally important to the animal. With none of them can it safely dispense. The starch is necessary to supply the wants, so to speak, of the respiration; the gluten to build up the substance of the muscles; the fat to lubricate the joints, to round off the extremities of the bones, to fill up the cellular tissue, and to enable the muscles to play freely among each other; while the saline and earthy constituents of the plant yield the salts of the blood and other animal fluids, and the earthy phosphates and carbonates of the bones.—*Edinburgh Review*, No. 163.

SELECTIVE POWER OF ORGANISMS.

Both Plants and Animals (says Dr. George Wilson, who has beautifully illustrated this subject) are found to reject substances which are in abundance about them, and to appropriate others which are scantily provided by nature and can only be very slowly accumulated, even in favourable circumstances. A land plant, for example, finds in the soil which supports it much of the earth or oxide *alumina*, and very little of the alkalies potash and soda; yet it totally refuses to take any of the *alumina*, while it untiringly searches for and absorbs the alkalies, or dies if it cannot find them. A graminivorous animal finds in its food much silica, yet, with the exception of very little in the hair, and mere traces elsewhere, silica is absent from all its structures. On the other hand, it finds in its food very little phosphate of lime, but it appropriates the whole of it, expending it on the nutrition of every tissue, but especially in constructing its bones.

If we had the means of comparing the weight of an elephant's tusk (say of 150 lbs.) with the tons of vegetable matter which the animal had to devour, and the hundredweights of silica which it had to reject, before it obtained a sufficient amount of phosphate of lime to form the ivory of a single tooth, we should have a startling proof that there is no necessary connection between the quantity of raw material offered to an organism and the quantity of that material appropriated by it. In every botanic garden we see plants requiring very different kinds of food growing side by side, and living on the same soil, from which each plant selects for itself exactly what it requires.

A still more striking example of selective action is afforded by the plants and animals which simultaneously develop them-

selves from the same medium, such as the sea. In any rocky pool, when the tide is out, and in every thriving drawing-room aquarium, one may find the graceful plants which we call seaweeds sipping from the mingled waters their daily fractional dose of iodine; housed sea-snails sucking from it carbonate of lime from their shells; restless fishes extracting from it phosphate of lime to strengthen their bones; and lazy-like sponges dipping successfully into it for silica to distend the mouths of their filters.

Thus no creature is a fortuitous course of atoms. Each is as definite and constant in its chemical composition as it is in its mechanical structure or its external form. A bird does not more certainly in successive generations instinctively build its nest in the same way than, from the first moment of its embryonic life, it unconsciously builds its own body out of the same materials, gathering lime to its bones, iron to its blood, and silica to its feathers.

In this way, through unnumbered centuries, each tribe of organisms has from the period of its creation followed in its structural development a chemical formula of composition, which in the same species is constant, within narrow limits, for every one of its members; so that each plant and animal has a chemical as well as an anatomical individuality. — *On Chemical Final Causes; Edinburgh Essays*, 1856.

USE OF PLANTS IN THE ECONOMY OF NATURE.

That the office of plants in the economy of the world is not so much to purify the air for animals as to supply them with nourishment, may be argued from the nature of the operation in which oxygen gas is liberated by vegetables. Plants take carbonic acid, water, &c. from the air, and decompose them, giving back to the atmosphere a part of the oxygen; while they transform the rest of the materials into vegetable fabric, or into vegetable products (mostly the prepared materials of vegetable fabric). The raw materials used contain more oxygen than the vegetable matter produced from them does. The surplus oxygen has to be eliminated, and is therefore given off in a free state, which appears to be the essential thing here; — the formation of vegetable fabric, or of organic matter, by which alone the plant can grow, form its parts, and continue to exist; or the evolution of the oxygen gas necessarily separated in the process, and which has to be got rid of.

SERVICES OF NITROGEN TO PLANTS.

There are almost countless compounds contained in nitrogen which are capable of being dissolved by water. Some of

these descend from the air with the falling rain, some exist in the waters of our springs, some in the manures we add to the land, and some are formed during the decay of the vegetable matter in the soil. These enter into the roots, and no doubt supply a variable proportion both of carbon and nitrogen to the growing plant. And lastly, over the whole surface of the globe, wherever animal and vegetable substances are undergoing slow decomposition, there is a constant tendency to the production of nitric acid ; and in the air, whenever the lightning flashes, it is formed in minute quantity from the elements of the air itself. We cannot tell how much of this acid is continually produced in nature, but it must be very great, and it may safely, we think, be regarded, in the general vegetation of the globe, as one of the main forms of combination in which nitrogen enters into the circulation of living plants.—*Edinburgh Review*, No. 163.

Another writer observes : “ We may say that the nitrogenous constituents of plants embody a high degree of force, which is destined ultimately to manifest itself in the sensible motions of animals. And it is a curious confirmation of this view, that if these substances pass into decomposition without being organised into muscle, they set free a large amount of chemical force ; all those *ferments* which have so remarkable a power of exciting chemical changes in other compounds, being members of this group.”—*National Review*, No. 8

SILICEOUS EPIDERMIS OF PLANTS.

Sir Humphry Davy's first scientific discovery was the detection of siliceous earth in the epidermis of the cannæ, reeds, and grasses. A child had accidentally noticed the emission of a faint light when two pieces of bonnet-cane were rubbed together. On examining the fact, Davy ascertained that on striking the pieces together vivid sparks were produced, similar to those emitted by the collision of flint and steel. Davy observes of this very beautiful discovery, in *Lectures on Agricultural Chemistry*, that “ the siliceous epidermis serves as a support, protects the bark from the action of insects, and serves to perform a part in the economy of these feeble vegetable tribes similar to that performed in the animal kingdom by the shell of the crustaceous insects.”—*Weld's History of the Royal Society*.

Chemistry of Food.

VALUE OF NITROGEN.

THE nutritive properties of Nitrogen have been greatly over-rated. Magendie says: "It is true that alimentary substances which contain little or no nitrogen are not nutritive; but to conclude, as is often done, that the proportion of nitrogen contained in one element gives exactly its nutritive power, is to greatly exceed the truth deduced from the experiments which have been made on this point of physiology. Many highly nitrogenous substances are not nutritious."

HOW ANIMALS GROW FAT.

Liebig, failing to discover sufficient oily matter in the food consumed by animals to account for their fat, maintained that this substance, which merely consists of drops of oil surrounded by a delicate animal membrane, in most instances resulted from the changing in the system of starch and sugar into oil. It was difficult to prove this, however necessary the inference; but at last an experiment of Milne-Edwards set the matter at rest. He confined some bees in a glass vessel, and gave them only sugar to eat. In the course of a few days, although they had not increased or decreased in weight, they had consumed a quantity of the sugar, and had formed a large quantity of wax; thus proving that the bees must have formed the wax from the sugar. The power possessed by the animal system of converting sugar into fat seems perfectly analogous with this in the bee of converting sugar into wax.

WHAT IS THE WORTH OF GELATINE?

In the animal body is found a substance called Gelatine, which is to its existence what cellulose is in the vegetable kingdom. Although often taken into the system with animal food, especially in soups and jellies, from experiments made in France and Belgium there appears to be no evidence to show that Gelatine is used in forming any of the proteinaceous tissues of the body; at the same time it is not improbable that the Gelatine may be appropriated for renewing the gelatinous portions of the tissues, which are very extensive in the animal

body. Hence, although Gelatine is not nutritious in the sense of nourishing the actively vital parts of the body, it may assist in keeping up certain parts of the fabric. It need not, then, be rejected from our food; but it cannot be too widely known, that, as the basis of soups and jellies, it may be administered under the supposition of being nutritious, and thus lead, if used alone in diet, to disastrous results.

HOW THE BODY IS NOURISHED BY FOOD.

The food consumed by man produces two, and only two, effects necessary to his existence. These are, first, to supply him with that animal heat without which the functions of life would stop; and secondly, to repair the waste constantly taking place in his tissues, that is, in the mechanism of his frame. For each of these separate purposes there is a separate food. The temperature of our body is kept up by substances which contain no nitrogen, and are called non-azotised; the incipient decay in our organism is repaired by what are known as azotised substances, in which nitrogen is always found. In the former case the carbon of non-azotised food combines with the oxygen we take in, and gives rise to that internal combustion by which our animal heat is renewed. In the latter case, nitrogen having little affinity for oxygen,* the nitrogenous or azotised food is as it were guarded against combustion, and being thus preserved, is able to perform its duty of repairing the tissues, and supplying those losses which the human organism constantly suffers in the wear and tear of daily life.

VEGETABLE AND ANIMAL FOOD.

As a sect has arisen of persons who deny the propriety of man's taking animal food, it may be well to examine the evidence on which his claim to be regarded as a flesh animal rests. We shall dismiss the sentimental objection that life ought not to be taken as unworthy of serious refutation, as every one must feel that for carnivorous animals to prey upon lower animals is a natural law.

First, the experience of the races and nations of men who partake of animal food is decidedly in its favour. Amongst the northern and European nations this practice is universal; and it is precisely among these people that we see the greatest amount of physical power and moral and intellectual development existing; whilst those individuals

* "Of all the elements of the animal body, nitrogen has the feeblest attraction for oxygen; and what is still more remarkable, it deprives all combustible elements with which it combines, to a greater or less extent, of the power of combining with oxygen, that is, of undergoing combustion."—*Liebig's Familiar Letters on Chemistry.*

who partake most largely or exclusively of a vegetable diet are alike physically, intellectually, and morally degraded. Again, among those classes who get the least animal food, as also in those public establishments where meat is only sparingly allowed, mortality is greatest, and disease is most rife. The disease most commonly generated by an exclusively vegetable diet is scrofula, and when traceable to this cause, the most speedy remedy is the addition of animal food to the diet. And there is no surgeon or physician connected with the great medical charities of this country but has, unfortunately, ample opportunities of witnessing the ill effects of a vegetable diet, and the benefit in such cases of the administration of animal food.

It has also been found, not alone as a matter of general personal experience, but by direct experiment, that animal food is more digestible than vegetable food; as in the case of St. Martin, where Dr. Beaumont, through a gun-shot wound never healed, placed various kinds of food in the stomach, and was thus enabled to ascertain how long each required to digest; and it was found that the flesh of animals was much more digestible than any of the more nutritious forms of vegetable food, as bread, and the preparations of flour. (*See ante*, p. 157.)

To this evidence may be added that on examination of the organs in man, it will be found that they are a true mixture of those of the vegetable-feeding and carnivorous animals. His teeth are partly adapted for grinding, whilst some of them are supplied with the sharp projections which are characteristic of the carnivora, thus evidently adapting them for the mastication of both vegetable and animal food. A slight lateral movement of the lower jaw with the up-and-down action is expressive of the subserviency of his structure to a mixed diet. In the stomach also we find indications of the same intermediate position in its structure; and the same conclusion is forced upon us, that it is part of the apparatus of an animal intended for subsisting upon a diet composed of animal and vegetable substances.—*Abridged from Dr. Lankester's Letters on Diet.*

NUTRIMENT IN APPLES.

Chemical researches by Mr. J. H. Salisbury, of Albany, show that good varieties of the Apple are richer in those bodies which strictly go to nourish the system than potatoes are; or, in other words, to form muscle, brain, nerve, and, in short, assist in sustaining and building up the organic part of all the tissues of the animal body.

HOW TO MAKE BREAD OUT OF WOOD.

Dr. Prout has clearly proved that all the chief alimentary matters employed by man may be reduced to three classes, viz. saccharine, oily, and albuminous substances, the most perfect specimens of which are respectively sugar, butter, and the white of eggs. The saccharine principle includes the vegetables, comprehending all those substances, whatever their

sensible properties may be, into the composition of which hydrogen and oxygen enter in the proportion in which they form water,—for example, the fibre of wood, which chemists call *lignine*, that is, the nutritive property of the woody fibre; and by means of skilful manipulation, Professor Auterith of Tübingen, in 1834, succeeded in making a *tolerably good quartern-loaf out of a deal board*. First, every thing that was soluble in water was removed by maceration and boiling; the wood was then reduced to fibres, dried in an oven, and ground as corn, when it had the taste and smell of corn-flour. Water and the sour leaven of corn-flour were then added, to make a spongy bread, which, being baked, had much crust and a much better taste than what in times of scarcity is prepared from bran and husks of corn. Wood-flour also, boiled in water, forms a nutritious jelly; the Professor also ate it in the form of gruel or soup, dumplings, and pancakes, which were palatable and wholesome.

Professor Brande, in his *Lectures*, thus records an analogous result: “Gum and sugar (grape variety) may be obtained by the action of sulphuric acid on woody fibre. *Bread* has also been made of this substance; indeed, before me is a specimen of such bread imported from Sweden. Seeing the close relation between the composition of starch and lignine, the conversion of the latter into bread does not appear so remarkable. I cannot say much, however, in favour of the bread; indeed, the quality of all such specimens from a similar source which have come under my notice has been very poor.”

HOW BREAD BECOMES STALE.

In a discussion by the French Academy respecting the grave yet apparently simple question, why Bread becomes stale, M. Boussingault has laid down that staleness is not, as is generally supposed, caused by the proportion of water diminishing; but arises from a molecular state, which manifests itself during the cooling, becomes afterwards developed, and persists as long as the temperature does not exceed a certain limit. M. Thénard maintains that staleness is caused by bread being a hydrate which heat softens, but to which a lower temperature gives more consistency.

VALUE OF RICE AS FOOD.

From the earliest period the most general food in India has been rice, which is the most nutritive of all the cerealia, contains an enormous proportion of starch (from 83·8 to 85·07 per cent), and yields to the labourer an average return of at least sixty-fold.

IMPROVED BUTTER-MAKING.

It has been ascertained by experiment in America, that if at the exact moment when the butter begins to separate from the cream, more cream is gradually added, the churn continuing to be briskly worked, the effect will be magical, and the yield of butter immediate. If, however, the fresh cream be poured in too fast, it will stop the process; and it will not answer to let the agitation cease for an instant.

WHAT IS THE WORTH OF CHEESE?

Although casein as dissolved in milk is very digestible, it becomes, when separated and known by the name of cheese, very indigestible. When milk is deprived of its butter, and the pure casein made into cheese, as is the case with some English cheeses (those from Suffolk for example), it becomes so hard as scarcely to be digestible. But in most cases the casein is curdled with the butter, and a large percentage of this substance is found in all good cheeses.

PRESERVATION OF FOOD.

That meat can be preserved at temperatures below the freezing-point is well known, of which fact the frozen markets of St. Petersburg afford an example; but the most remarkable instance of preservation by frost is that of the Siberian mammoth, which is supposed to have been buried under the ice several thousands of years, and when first exposed from its icy covering the flesh was quite fresh, and was eaten by dogs. The effect of exposure to air is to decompose by the combination of the oxygen of the atmosphere with the complicated compounds of animal organisation, and that effect is increased by the presence of moisture. It is a common opinion that the light of the moon facilitates decomposition; the foundation of which notion may be traced to the circumstance that on clear moonlight nights there is a greater deposition of dew than under a cloudy sky.

Boiling checks fermentation in organic substances, by which means, the oxygen of the atmosphere being excluded, meats are preserved for long voyages; "certainly one of the most important contributions to the practical benefit of mankind ever made by science, and for this we are indebted to Gay-Lussac."—*Liebig*.

The Laboratory.

THE Laboratory of the Alchemists must be sought in the backgrounds of the pictures of the old painters, who have so vividly portrayed that race of inventors. The figure in the Frontispiece to the present volume is from a work of this class, in the Orleans collection, painted by David Teniers in the 17th century.

Three distinguished philosophers of the 17th century are recorded as having cheered their hours of captivity or retirement from the strife of war in the more genial pursuits of the laboratory. Sir Walter Raleigh passed the early years of his imprisonment in the Tower of London, as we shall presently more fully describe. The Marquis of Worcester wrote a portion of his *Century of Inventions* whilst confined in the same gloomy fortress. It is said that he was preparing some food in his apartment, when the cover of the vessel, having been closely fitted, was, by the expansion of the steam, suddenly forced off, and driven up the chimney. This circumstance, attracting the Marquis's attention, led him to a train of thought which terminated in the completion of an invention, which he denominated a "Water-commanding Engine;" and when Cosmo de' Medici, Grand-Duke of Tuscany, visited England in 1656 (at which time the Marquis was a close prisoner in the Tower), his engine was exhibited at Lambeth, as recorded in the Grand-Duke's Diary.

Prince Rupert, among his chemical inventions, formed the composition now called Prince's Metal, of which candlesticks and small kitchen pestles and mortars are made: this is an alloy of copper and zinc, which contains more copper than brass does, and is prepared by adding this metal to the alloy. To the list of the Prince's inventions must be added a mode of rendering black-lead fusible, and re-changing it into its original state. To him also has been attributed the toy that bears his name as "Rupert's Drop;" that curious bubble of glass which has long amused children and puzzled philosophers.

The Prince also discovered a method of boring guns, which was afterwards carried into execution in Romney Marsh by a speculator; but some secret contrivance of annealing the metal was not understood except by Rupert, and the matter died

him. His mode of tempering the Kirby fish-hooks was amongst his lesser discoveries.

The Prince also built an experimental glass-house adjoining Chelsea College, which proved a great hindrance to the letting of the college and lands, when Sir Jonas More interfered on behalf of the Royal Society, and so the nuisance was abated.

After the Restoration, Prince Rupert, who had been appointed by Charles II. Governor of Windsor Castle, had the Keep, or Round Tower, as his official residence; and here he fitted up a laboratory, with a forge and implements for experimenting in his favourite science, metallurgic chemistry.

In the account of Sir Isaac Newton's college-life at Cambridge, we find some interesting particulars of his love of experiments in chemistry and pharmacy. His hair turned gray at the age of thirty, which he jocosely attributed to the great number of experiments he made with quicksilver, "as if from hence he took so soon that colour." He suspected himself to be inclined to consumption, and made for his own use Leucatello's Balsam, from the following recipe in his own hand:

Put Venus turpentine one pound into a pint of the best damask rose-water; beat these together till it look white, then take four ounces of bees'-wax, red sanders half an ounce, oil of olives of the best a pint, one ounce of the oil of St. John's wort, and half a pint of sack. Set it (the sack) on the fire in a new pipkin, add to it the oil and wax, let it stand on a soft fire where it must not boil, but melt it till it be scalding hot. Then take it off. When it is cold, take out the cake, and scrape off the dirt from the bottom. Take out the sack, wipe the pipkin, put in the cake again, set it on the fire, let it melt together, and then put in also the turpentine and sanders; let them not boil, but be well melted and mixed together; take it off and stir it now and then till it is cold. If you would have it to take inwardly, add to it when it is off from the fire half an ounce of powder of scuchineal (cochineal), and a little natural balsam.

For the measles, plague, or small-pox, a half an ounce in a little broth, take it warm, and sweat after it. And against poison and the biting of a mad dog, for the last you must dip lint, and lay it upon the wound, besides taking it inwardly. There are other virtues of it: for wind, cholic, anoint the stomach, and so for bruises.

Newton's application to his studies was intense. One of his few visitors was M. Vigani, a native of Verona, who, after having taught chemistry at Cambridge for twenty years, was appointed by the University Professor of Chemistry; and Dr. Bentley fitted up for him in Trinity College an old lumber house as an elegant chemical laboratory, in which he lectured for some years. Newton rarely went to bed till two or three o'clock, sometimes not till five or six, lying about four or five hours, especially at spring and fall of the leaf: at these times he used to employ about six weeks in his laboratory, the fire scarcely going out either night or day, he sitting up one night,

and his assistant the other, till he had finished his chemical experiments, "in the performances of which he was most accurate, strict, exact."

"He was very curious in his garden, which was never out of order, in which he would at some seldome time take a short walk or two, not enduring to see a weed in it. On the left end of the garden was his elaboratory, near the east end of the chapel, where he at these set times employed himself in with a great deal of satisfaction and delight."*

We have no special account of the Laboratory of the Royal Society. The Museum was commenced in 1665; then was "the collecting a repository, the setting up a chemical laboratory, a mechanical operatory, an astronomical observatory, and an optick chamber; next year Evelyn presented the table of veins, arteries, and nerves, which he had made 'out of the natural human bodies,' in Italy." Sir R. Moray presented "the stones taken out of Lord Balcarras's heart, in a silver box;" and "a bottle full of stag's tears." Hooke gave "a petrified fish, the skin of an antelope which died in St. James's Park, a petrified foetus," and other rarities. In 1681, when Dr. Grew published his curious catalogue, the museum contained several thousand specimens of zoological subjects and foreign curiosities: among the eighty-three contributors are Prince Rupert, the Duke of Norfolk, Boyle, Evelyn, Hooke, Pepys, &c.

The following list from the catalogue of the articles in the museum or repository of the society, when located at Gresham College, *circ.* 1708, will give some idea of the chemical rarities of that period.†

Things relating to Chymistry and other parts of Natural Philosophy.

The Oyl, Spirit, Volatile and fixed Salts both of the Serous and Gummous parts of Humane Blood, and that of an Ox.

The Oyl of Tobacco: One or two drops of it put on a Cat's Tongue killed her in less than a minute before the R. Society. In Lint held between the teeth of those that smoak gives ease or cures the Tooth-ache, but apt to make those sick who do not take Tobacco. Also Oyls of Lawang Bark, Camphire, Mace, and several Salts. Sal-ammoniack sublimated, also the Spirit thereof.

A Phosphorus (Hermetick), which is a mix'd matter, and being exposed about half a minute to the Sun, Day-light, or Candle, or Fire, will shine in the dark for some minutes: this made by Dr. Slare. Mr. Isaac experienced that if he exposed it to the light a little before Sun-rise, it presented a bright rosy hue, and advances in fiery colour as the Sun approaches the Meridian, and after Sun-set declines to a pale wan colour.

Instruments relating to Natural Philosophy.

An Air-pump (contrived by the Honourable R. Boyle Esq.). an Engine to exhaust the Air out of any vessel.

* See the account of Newton's Rooms and Laboratory at Cambridge *Curiosities of Science*, First Series, pp. 7, 8.

† Hatton's *New View of London*. 1708.

The Condensing Engine, whereby much air is crowded into a small room.

A Weather-Cock, by Sir Chr. Wren, augmented by Mr. R. Hook.

An Instrument whereby the quantity of Rain that falls in any time on any piece of ground is measured, contrived by Sir Christ. Wren.

The Model of an Instrument to fetch earth and other bodies from the bottom of the sea, contrived by Dr. Hook.

A Lamp Furnace (by the same Gent.), designed for the hatching of Eggs, in order to observe the process of generation; as also digesting of Liquors. Also by the same Author, a pair of Semi-cylindrical Lamps, designed for poisoning the Liquor which is to feed the flame, to secure that it never dart the Flame, and also to keep it of equal strength.

The Model of an Eye, in which the Humors are represented by glasses of an answerable figure.

A Burning Glass, $\frac{1}{2}$ a foot diameter.

Another, i. e. two thin concave glasses set together, and so to be filled up with water when used; conceived and given by Bishop Wilkins.

A large Microscope with three glasses fitted for all manner of positions: it magnifies to 100 times the area's appearance to the Eye; also, a lesser.

An Otocoustick to help the Hearing, given by Bishop Wilkins; this is of ivory—there is another of copper, funnelled and belled in the middle; a third of tin, conical within it: the best is the first.

A pair of Hydrostatick Scales, used to examine the specific gravity of bodies, &c.

A Box of Anatomick Instruments, viz. Saws, Knives, Chisels, Forceps, Laver, Tenter, Syringe, Pipes, Probes, and Needles.

In 1710, the Society removed to a house in Crane-court, Fleet Street, "being in the middle of the town, and out of noise;" and here they established their library and museum. In 1782, they removed to New Somerset House, and transferred most of their older curiosities to the British Museum.

The laboratory of the London Institution, in the rear of the main building, erected in 1819, was designed by W. H. Pepys, F.R.S.: the apparatus in pneumatics, hydrostatics, electricity, and magnetism, are very perfect; but the great battery of 2000 double plates, 200 feet square, with which Sir Humphry Davy experimented, has long been destroyed.

The laboratory of the Royal Institution, "the workshop of the Royal Society," in the basement of the building, was originally fitted up on a scale of magnitude and completeness not before attempted in this country. Here is the vast apparatus with which Sir Humphry Davy discovered the composition of the fixed alkalis. The apparatus is of immense power, and consists of 2000 separate parts, each composed of ten double plates, and each plate containing 32 square inches; the number of double plates being 2000, and the whole surface 128,000 square inches.

In 1802, Davy began his brilliant scientific career at the Royal Institution, where he remained till 1812; here he constructed his great voltaic battery, and commenced the mineralogical collection now in the

Museum. His lectures were often attended by 1000 persons: his youth, his simplicity, his natural eloquence, his chemical knowledge, his happy illustrations and well-conducted experiments, and the auspicious state of science, ensured Davy great and instant success.

The enthusiastic admiration with which he was hailed can hardly be imagined now. Not only men of the highest rank,—men of science, men of letters, and men of trade,—but women of fashion and blue-stockings, old and young, pressed into the theatre of the Institution to cover him with applause. His greatest labours were his discovery of the decomposition of the fixed alkalies, and the reëstablishment of the simple nature of chlorine: his other researches were the investigation of astringent vegetables, in connection with the art of tanning; the analysis of rocks and minerals, in connection with geology; the comprehensive subject of agricultural chemistry; and galvanism and electro-chemical science. He was also an early but unsuccessful experimenter in the photographic art.

Of the lazy conservative spirit and ludicrous indolence in science, which at this time attempted to hoodwink the public, a quaint instance is recorded of a worthy professor of chemistry at Aberdeen. He had allowed some years to pass over Davy's brilliant discovery of potassium and its congeneric metals without a word about them in his lectures. At length the learned doctor was concussed by his colleagues on the subject, and he condescended to notice it. "Both potash and soda are now said to be metallic oxides," said he; "the oxides, in fact, of two metals, called potassium and sodium by the discoverer of them, one Davy in London, a verri troublesome person in chemistry."*

Davy first communicated his discovery of the Safety-Lamp to the Royal Society in 1815. This was followed by a series of papers, crowned by that read on the 11th of January 1816, when the principle of the Safety-Lamp was announced, and Sir Humphry presented to the Society a model made by his own hands, which is to this day preserved in the collection of the Royal Society at Burlington House.

The requisites for the proper arrangement of, and the necessary instruments for, a laboratory may be seen at length in Dr. Faraday's *Chemical Manipulation*; or in Dr. Lardner's *Chemistry for Schools*.

SIR WALTER RALEIGH A CHEMIST.

Sir Walter Raleigh appears to have exercised, to a considerable extent, the powers of his cultivated mind in order to cheer the gloom of his long imprisonment in the Tower of London. The first few years he devoted to the pursuits of chemistry. In a letter from Sir William Wade, Lieutenant of the Tower, dated 1605, we are told that "Sir Walter Raleigh hath like access (with Cobham) of divers to him; the door of his chamber being always open all the day to the garden, which indeed, is the only garden the lieutenant hath. And in the garden he hath converted a little hen-house to a still-house

* From *Stories of Inventors and Discoverers in Science and the Useful Arts*, 1866.

where he doth spend his time all the day in distillations." One of these results we find thus recorded in the State-Papers edited by Mrs. Everett Green :

"29 Sept. 1608.—This day Sir W. R. fell to discoursing to me of the wonders he had done for the benefitt of the kingdom, how much he had spent for the service thereof, in discoveryes, &c., and after fell to tell me of his inventing the means to mak salt water sweet by furnaces of coper in the forecastle ; and distilling of the salt water as it wer by a buket putting in a pipe att once, and within a quarter of an hour it will run lyk a spiggott, so that he hath by that distilled water given 240 men every day quarts a peece and the water as sweet as milk. From that he fell to telling me upon my questions the cause of the salt-ness of the sea water by mountains of salt in most places and salt-peeter upon euery rock and cliff contrary to Aristotle, and that the cause of the greeness of all things that grows out of the erth is by the vitriol that is in the erth which is the salt of the erth, for lett a man with water gett all the salt out of erth, ther will nothing grow ther."

Raleigh's prison-lodging is thought to have been in the second and third stories of the Beauchamp Tower. He devoted some time to medical chemistry ; and here he prepared his celebrated Cordial. During the last illness of Henry Prince of Wales (to whom Raleigh was strongly attached), the Queen applied to Sir Walter for some of his cordial, the good effects of which she had herself experienced. Raleigh, in a letter of condolence, hazarded his belief that his cordial "would certainly cure the prince, or any other, of a fever, except in case of poison."

Raleigh's Cordial was held in such high reputation in the reign of Charles II. that a treatise on the preparation was then written, under the auspices of that monarch. It was entitled *Discours sur le Grand Cordial de Sir Walter Raleigh*, and was published in 1665. The original recipe is given by the author, Le Febure ; but Sir Kenelm Digby and Sir Alexander Fraser introduced other ingredients. Evelyn, in his Diary, under the date 1662, says : "I accompanied his Majesty to Monsieur le Febure, his chemist (and who had formerly been my master in Paris), to see his accurate preparation for the composing Sir Walter Raleigh's rare cordial. He made a learned discourse before his Majesty, in French, on each ingredient." Raleigh appears to have kept the preparation of his cordial a secret during his life. The formula is simplified in the *London Pharmacopœia* under the name of "Aromatic Confection:" it consists of zedoary and saffron, distilled water, compound powder of crabs' claws, cinnamon, nutmegs, and cloves, smaller cardamon seeds, and double refined sugar, made into a confection.

DAVY, WOLLASTON, AND JAMESON, IN THE LABORATORY.

The change in the practice of the Royal Society with respect to their Laboratory experiments was thus explained by Sir Humphry Davy in his Address on taking the President's chair in 1820,—within a few years of his apprenticeship to an apothecary, when his means were so humble that he was unable to purchase apparatus for philosophical experiments.

In the early part of our establishment (said the President), when apparatus was procured with difficulty, when the greatest philosophers were obliged to labour with their own hands to frame their instruments, it was found expedient to keep in the rooms of the Society a collection of all such machines as were likely to be useful in the progress of experimental knowledge; and curators and operators were employed, by whom many capital experiments were made under the eyes of the Society. But since the improvement of the mechanical and chemical arts has afforded great facilities as to the means of carrying on experimental research, the Transactions of the Fellows recorded by the Society have, with some few exceptions, been performed in their own laboratories, and at their own expense. It is, however, possible that experiments of great importance, requiring funds which few individuals can command, may be suggested; and it is to be hoped that on such occasions the proposers will not fail to recur to the Society.

Sir Humphry next refers to “grand and expensive apparatus” then in public establishments, the advantage of which was becoming available.

Yet such costly means were not indispensable for the study of chemistry, as the experience of its distinguished professors shows. Dr. Wollaston's knowledge was more varied, and his taste less exclusive, than any other philosopher of his time, except Mr. Cavendish; but optics and chemistry are the two sciences for which we are under the greatest obligations to him. He had a peculiar turn for contriving pieces of apparatus for scientific purposes. By means of his reflective goniometer crystallography has acquired a great degree of perfection; and his sliding-rule for chemical equivalents furnishes a ready mode for calculating the proportions of one substance necessary to decompose a given weight of another.

Dr. Wollaston was accustomed to carry on his experiments in the greatest seclusion, and with very few instruments. His laboratory was sealed to even his most intimate friends. Dr. Paris relates that a foreigner once called on Wollaston with letters of introduction, and expressed an anxious desire to see his laboratory. “Certainly,” he replied, and immediately produced a small tray containing some glass tubes, a blowpipe, two or three watch-glasses, a slip of platinum, and a few test-tubes. Upon another occasion, after inspecting Mr. Children's grand galvanic battery, Wollaston, within a tailor's thimble, com-

pleted a galvanic arrangement by means of which he heated a platinum wire to a white heat.

Mr. Brande records that Dr. Wollaston's "uncommon tact, neatness, and dexterity as an experimental chemist will never be forgotten by those who had an opportunity of witnessing his performance of any analytical operation : he practised a peculiar method of microscopic research, in which he willingly instructed those who asked his information ; and we owe to him numerous abbreviations of tedious processes, and a variety of improvements in the application of tests, which have gradually become public property, although he never could be induced to describe his manipulations in print, or to communicate to the world his happy and peculiar contrivances." Towards the close of 1828, however, feeling his end approaching, and being personally unable to write accounts of such of his discoveries and inventions as he was reluctant should perish with him, he employed an amanuensis, and in this manner communicated some of his most valuable papers to the Royal Society. Within a month of his death, he invested in the Funds 2000*l.* in the name of the Royal Society, the interest to be applied to the promotion of science.* Of this amiable philosopher Dr. Henry says :

In chemistry Dr. Wollaston was distinguished by the extreme nicety and delicacy of his observations ; by the quickness and precision with which he marked resemblances and discriminated differences ; the sagacity with which he devised experiments, and anticipated their results ; and the skill with which he executed the analysis of fragments of new substances, often so minute as to be scarcely perceptible to ordinary eyes. He was remarkable, too, for the caution with which he advanced from facts to general conclusions ; a caution, which, if it sometimes prevented him from reaching at once to the most sublime truths, yet rendered every step of his ascent a secure station, from which it was easy to rise to higher and more enlarged inductions.—*Elements of Chemistry.*

The late Professor Jameson first submitted his ideas to the public as a mineralogist in an Essay on Gems, which he contributed, when a young man, to Dr. Anderson's periodical, the *Bee*. At college, Jameson was very assiduous in the chemical class ; he paid especial attention to mineralogical information and analytical chemistry. Dr. Hope, who filled the chemical chair, displayed the first oxyhydrogen blowpipe, which was constructed

* Dr. Wollaston died Dec. 22, 1828, of disease of the brain. In spite of severe suffering, his faculties were unclouded to the last. When he was nearly in the last agonies, one of his friends having observed loud enough for him to hear, that he was not conscious of what was passing around him, he made a sign for pencil and paper. He then wrote down some figures, and after casting up the sum, returned the paper. The amount was right. We quote this anecdote from Mr. Weld's *History of the Royal Society*, in which he notes : "It is very remarkable that no life of Wollaston exists, although his reputation stands so high. It has been observed, that had he been a German or a Frenchman, the want would have been long since supplied."

under Mr. Jameson's superintendence—an instrument indispensable in analytical mineralogy. Thus attending lectures, and studying the subjects lectured on, he did not consider these all that were necessary to form a chemist; he felt unless he could handle a crucible as well as name it, unless he could collect the gases as well as describe them, he was only a nominal chemist. His father, entering into his views, assigned him a suitable room for his laboratory, and fully supplied him with what apparatus it required, and allowed him necessary attendants in assisting him in his experiments. It shows the practical character of Jameson's mind to learn that when he left his own country for Freyberg in 1800, to study mineralogy and geology, under the learned and famous Werner, he worked in the mines there under the rules laid down by his master, and went through the same drudgery and the same kind of work as the common miner, by which means he acquired much valuable knowledge.

Sir Humphry Davy, by way of illustrating the advantages which students of his day possessed over their predecessors, says :

The apparatus essential to the modern chemical philosopher is much less bulky and expensive than that used by the ancients. An air-pump, an electrical machine, a voltaic battery (all of which may be upon a small scale), a blowpipe apparatus, a bellows and forge, a mercurial and water-gas apparatus, cups and basins of platinum and glass, and the common reagents of chemistry, are all that are required. All the implements absolutely necessary may be carried in a small trunk; and some of the best and most refined researches of modern chemists have been made by means of an apparatus which might with ease be contained in a small travelling carriage, and the expense of which is only a few pounds. The facility with which chemical inquiries are carried on, and the simplicity of the apparatus, offer additional reasons to those I have already given for the pursuit of this science. It is not injurious to the health: the modern chemist is not like the ancient one, who passed the greater part of his time exposed to the heat and smoke of a furnace, and the unwholesome vapours of acids and alkalis, and other menstrua, of which for a single experiment he consumed several pounds. His processes may be carried on in the drawing-room, and some of them are no less beautiful in their appearance than satisfactory in their results. It was said by an author belonging to the last century of Alchemy, that "its beginning was deceit, its progress labour, and its end beggary:" it may be said of modern chemistry that its beginning is pleasure, its progress knowledge, and its objects truth and utility.

Sir Humphry then recommends to the student patience, industry, and neatness in manipulation; accuracy and minuteness in observing and registering the phenomena which occur. A steady and a quick eye are most useful auxiliaries; but there have been very few great chemists who have preserved these advantages through life; for the business of the laboratory is often a service of danger; and the elements, like the refrac-

tory spirits of romance, though the obedient slave of the magician, yet sometimes escape the influence of his talisman and endanger his person. Both the hands and eyes of others, however, may be sometimes advantageously made use of.

Liebig, speaking of the progress and development of modern chemistry, thus illustrates the means and implements employed by the chemist in his labours. Without glass, cork, platinum, and caoutchouc (he says), we should probably at this day have advanced only half as far as we have done. In the time of Lavoisier only a few, and those very rich persons, were able, on account of the costliness of apparatus, to make chemical researches.

The wonderful properties of glass are well known : transparent, hard, colourless, unchanged by acids and most other liquids, and at certain temperatures more plastic and flexible than wax, it takes, in the hands of the chemist and in the flame of a proper lamp, the form and shape of every piece of apparatus required for the experiments.

What precious properties are combined in cork ! How little can any but chemists appreciate its value and recognise its good qualities ! We might rack our brains in vain in the hope of replacing cork as the ordinary means of closing bottles by any other substance whatever. Let us imagine a soft, highly elastic mass, which nature herself has impregnated with a matter having properties resembling wax, tallow, and resin, yet dissimilar to all these, and termed *suberin*. This renders it perfectly impermeable to fluids, and in a great measure even to gases. By means of cork we connect wide apertures with narrow ones ; with cork and caoutchouc we connect our vessels and tubes of glass, and construct the most complicated apparatus without the aid of the brass-founder and the mechanist,—without screws and stop-cocks. Thus the implements of the chemist are cheaply and easily procured, immediately adapted to any purpose, and readily repaired or altered.

Without platinum it would be impossible, in many cases, to make the analysis of a mineral. To dissolve it, or render it soluble, would destroy vessels of glass, porcelain, and all non-metallic substances. Crucibles of gold and silver would melt at high temperatures. But platinum is cheaper than gold, harder and more durable than silver, infusible at all temperatures of our furnaces, and is left intact by acids and alkaline carbonates.

To these means must be added the Balance. The great distinction between the manner of proceeding in chemistry and natural philosophy is, that one *weighs*, the other *measures*. The natural philosopher has applied his measures to nature for many centuries, but only for fifty years have we attempted to

advance our philosophy by *weighing*. Once adopted, it put an end to the reign of Aristotle in physics. Three of his elements—air, earth, and water—are now matters of history.

Fire is found to be but the visible and otherwise perceptible indication of changes in the forms of bodies.

Lavoisier investigated the composition of the atmosphere and of water with the Balance; that incomparable instrument (says Liebig) which gives permanence to every observation, dispels all ambiguity, establishes truth, detects error, or shows us that we are in the true path. The principal problem of the succeeding generation was to determine the composition of the solid matters composing the earth.*

THE HONOURABLE CHARLES AND EDWARD CHARLES HOWARD.

In Sir Humphry Davy's posthumous work, *Consolations in Travel*, one of the personages in "Dialogue the Fifth—the Chemical Philosopher," observes:

Eubathes.† I have often wondered that men of fortune and rank do not apply themselves more to philosophical pursuits: they offer a delightful and enviable road to distinction, one founded upon the blessings and benefits conferred on our fellow-creatures; they do not supply the same sources of temporary popularity as successes in the senate or at the bar; but the glory resulting from them is permanent, and independent of vulgar taste or caprice. In looking back to the history of the last five reigns in England, we find Boyles, Cavendishes, and Howards, who rendered these great names more illustrious by their scientific honours; but we may in vain search the aristocracy now for philosophers, and there are very few persons who pursue science with true dignity.

Of the first of the two members of the illustrious Howard family we possess some interesting memorials. At the Deepdene, near Dorking in Surrey, which for centuries formed a portion of the Howards' possessions, lived the Hon. Charles Howard, son of the seventh Earl of Arundel. Evelyn, in his *Diary*, describes his visit here, August 1, 1655: "I went to Dorking to see Mr. Charles Howard's amphitheatre, garden, or solitaire recess, being fifteen acres, environ'd by a hill. He showed us divers rare plants, caves, and an elaboratory." Aubrey, who visited the place between 1672 and 1692, describes Mr. Howard as "a Christian Philosopher, who, in this iron age, lives up to that of the primitive times." Here chemistry was his favourite pursuit, "for the more commodious prosecution of which he erected laboratories; and in subterranean grots formed for that purpose had furnaces of different kinds, the

* Selected and abridged from *Familiar Letters*.

† The character of Eubathes bears a striking resemblance to that of Dr. Wollaston; and there is little doubt that Davy intended it for a portraiture of his brother chemist.

flues of which in some places are yet to be seen." Mr. Howard died in 1714, and was interred in a vault in Dorking Church. In the original garden at the Deepdene, affixed to some old brickwork that formed part of the laboratory, is placed a tablet bearing the following tribute to the Philosopher's character, by Lady Burrell:

This votive Tablet is inscribed to the Memory of the Honourable CHARLES HOWARD, who built an Oratory and Laboratory on this spot. He died at the Deepdene, 1714.

" If Worth, if Learning, should with fame be crown'd,
 If to superior Talents fame be due,
 Let HOWARD's virtue consecrate the ground
 Where once the fairest flowers of Science grew.
 Within this calm retreat, th' illustrious Sage
 Was wont his grateful orisons to pay;
 Here he perus'd the legendary page.
 Here gave to Chemistry the fleeting day.
 Cold to Ambition, far from Courts remov'd,
 Though qualified to fill the Statesman's part,
 He studied Nature in the paths he lov'd,
 Peace in his thoughts, and Virtue in his heart.
 Soft may the breeze sigh through the ivy-boughs
 That shade this humble record of his worth;
 Here may the Robin undisturb'd repose,
 And fragrant flow'rs adorn the hallow'd earth."

In the picturesque rearrangement of this portion of the grounds of the Deepdene, by the late Mr. Thomas Hope,* and his eldest son Mr. Henry Thomas Hope, the present possessor of the estate, it is gratifying to find that this interesting memorial of genius and worth has been preserved with reverential care.

The possession of the Deepdene by the Howard family terminated in 1792; so that the laboratory could scarcely have been the scene of those important experiments by which the Hon. Edward Charles Howard, by great skill in chemistry, so materially contributed to the improvement of the Sugar Manufacture. He resided for some time in a large garden-house fronting the Thames, in Surrey-street, Strand, part of the site of Arundel House and gardens; and here he may probably have experimented for his most valuable invention, now extensively used under the name of Howard's Vacuum-pan, patented in the year 1813, being the most useful application of the fact that liquids are driven off or made to boil at lower degrees of heat when the atmospheric pressure is lessened or removed. This valuable thought occurred to Mr. Howard, who thereby removed the chief difficulties attending the evaporation of the saccharine syrup. The saving of sugar and improvement in quality by this process were so great as to make the patent-right which secured the emoluments to the inventor and others very valuable.

* At the Deepdene, Mr. Hope wrote his *Anastasis*; and Mr. B. Disraeli his *mingaby*.

Lord Brougham characterises it as a process by which more money has been made in a shorter time, and with less risk and trouble, than was ever perhaps gained from an invention; and as "the fruit of a long course of experiments, in the progress of which known philosophical principles were constantly applied, and one or two new principles ascertained." (*The Objects, Advantages, and Pleasures of Science.*)

It is a curious fact in scientific discovery that the most profitable invention that was ever patented in this or any other country accidentally arose out of an application to Government to admit sugar for agricultural purposes. The Government applied to Mr. Howard, the accomplished chemist, to try some experiments for the purpose of ascertaining if sugar could be so effectually adulterated that it could not be again converted for culinary uses. For this purpose he mixed all kinds of noxious materials with it, but the question remained whether they could be again separated, and in the experiments to ascertain this, he discovered that not only could they be separated, but that the sugar was better and purer. Out of this arose Howard's patent for sugar-refining and the use of the vacuum-pan; the annual net income of which, from licenses granted for its use, at the rate of 1s. per cwt., yielded in some years between 20,000*l.* and 30,000*l.* One house in London alone paid 4,000*l.* per annum.—*Mining Journal.*

Mr. Howard's claim to the discovery has, however, been disputed. The late Mr. J. C. Robertson, the originator and editor of the *Mechanics' Magazine*, quoted the above statement "simply for the purpose of distinctly contradicting it in every particular, and of stating, what probably has not been stated before, but is nevertheless incontrovertibly true, that Mr. Howard, though he did benefit immensely by the invention in question, was not the real inventor of it. The illustrious Davy was the real inventor, from whom Howard did but knowingly borrow it; and any one who doubts the truth of this assertion may apply to Mr. Children for his testimony on this point."

Nevertheless, it is strange that Davy should have referred to Mr. Howard in eulogistic terms, had he thus appropriated the vacuum invention; for Sir Humphry refers to the chemist of his own time, and not to the philosopher of the Deepdene, who died early in the previous century.

STORY OF THE BLOWPIPE.

Hitherto we have spoken but incidentally of this valuable instrument, which, until the year 1738, was used by jewellers and others in soldering metals on a small scale; whence it derives its name, in the German language, *Löthrohr*, from *löthen*, to solder, and *röhr*, a tube. In the above year, Antony Swab, a Swedish counsellor of mines, employed the Blowpipe for determining the metals in the ores and minerals; but this did not receive any particular attention until Cronstedt proposed

his system of mineralogy, in which the arrangement is dependent on the chemical composition of the minerals. With the Blowpipe, and the employment of fluxes in his experiments, he founded a new department of chemical science.

The Blowpipe thenceforth became applied to chemical analysis, and the determination of mineralogical species. In Sweden, however, it still appears to have been studied with the greatest success; and Gahn exceeded his predecessors in the conception and execution of his experiments. As an instance of his power of detecting metallic bodies, we are told by Berzelius that he had often seen him extract from the ashes of a quarter of a sheet of paper distinct portions of copper, and that too before the knowledge of the occurrence of this metal in vegetables was known; and therefore before he could have been led, from this circumstance, to suspect its presence in paper.

Gahn left no account of his researches; but, fortunately for science, accident threw him in the way of Berzelius: and the assiduity of Gahn in this study, together with the circumstances to which we are indebted for the preservation of his labours, cannot be better told than in the words of Berzelius himself. "Gahn (says he) was never without his blowpipe, not even during his shortest journeys. Every new substance, or anything with which he was not previously acquainted, was immediately submitted to an examination before the Blowpipe; and it was indeed an interesting sight to observe with what astonishing rapidity and certainty he was thus enabled to determine the nature of a body, which from its appearance and exterior properties could not have been recognised. Through this constant habit of using the Blowpipe, he was led to invent many improvements, and to make many conveniencies, which he could not have at hand, whether at home or abroad. He examined the action of a number of re-agents, for the purpose of finding new methods of recognising bodies; and this he did in such detail, and conducted his operations with such accuracy, that all his results may be relied upon with the greatest confidence. Nevertheless, it never occurred to him to give a written description of his new or improved methods: he gave himself, however, all possible trouble to instruct all who were willing to learn, and many foreign men of science, who passed some time with him, have made known his great dexterity in this subject; but no one has communicated a perfect knowledge of his methods.

"I had the good fortune (adds Berzelius), during the last ten years of the life of this, in many respects, most remarkable man, to enjoy his most intimate acquaintance. He spared himself no trouble to communicate to me all the results of his experience, and I have consequently held it as a sacred

duty to allow nothing of his experience and of his labours to be lost." Such, then, is the origin of Berzelius's treatise on the Blowpipe, the highest authority upon the subject: it was translated into English by Mr. Children, F.R.S.

We have not space to detail the phenomena presented by the chemical elements and minerals when experimented on by the Blowpipe, which, we may add, is merely a brass tube, fitted with an ivory mouth-piece, and terminated by a jet having a small aperture by which a current of air is driven across the flame of a candle. The flame so produced is very peculiar.

Among the eminent workers in the Laboratory, the alchemists of mediæval Europe at first sight seem to stand in no true historical relation with the practical chemists of the present century. The seeking for the Alkahest or Universal Solvent, the Elixir of Life, and the Philosopher's Stone, were pursuits essentially unlike the sober and attainable aims of our own positive chemistry; and the men of our own laboratories would have taken little interest in the labours they involved, had it not been for the fact that those old scholastics, chasing images they were never to seize, worked out thousands of incidental results. If they were fond idealists, if they were visionaries, they were also chemists; and it is as chemists they deserve the recognition of the world. They worked with water, they worked with fire; they digested, boiled, distilled, roasted, burned, smelted, crystallised, set a-going putrefactions and fermentations; in short, they put in operation the same sorts of processes upon the same sorts of stuff as ourselves. Following their hereditary and antique elemental ideas, they were the first discoverers of those material principles and compounds which are commonly called chemicals; and the really great men among the alchemists were the busy students of such chemical reactions as could then be brought within the reach of the experimentalist, and made no personal pretensions to the Stone.

Soon after the time of Paracelsus, the alchemical theory and the alchemical practice of genuine observation in the laboratory fell asunder. The orient *al* departed, and left chemistry to pursue its own fortunes. The ancient eastern element did not, however, at once disappear from the earth; for it retained its devotees, no longer respectable, because behind their age, till the present century. On the other hand, those who chose the path of true chemistry addicted themselves with zeal to the finding out of all sorts of new chemicals and chemical reactions. To the positive labours of the laboratory there quickly succeeded a remarkable extension of practical or concrete chemistry; and the number of solid and liquid bodies, curious for their aspects or for their properties as chemical re-agents, acids, alkalies, salts, mixts, calxes, precipitates, sublimes, essences, oils, butters, and spirits, which were brought out of nature at this period was astonishing. It is impossible, indeed, for the most positive and the least speculative of the chemists of the present day, were it even a Rose and his platinum crucible, or a Plattner with his blowpipe, to over-value the amount of plain, honest, and sufficient, though merely preliminary, work that was done between the apotheosis of alchemy and the ascension of the phlogistic chemists.—*Selected and abridged from the North British Review*, No. 85.

Chemical Manufactures.

WHAT ARE CHEMICAL INVENTIONS ?

DAVY makes one of the characters in his Dialogue, "The Chemical Philosopher," thus eloquently recapitulate the invaluable benefits of applied chemistry to the arts of life.

You will allow that the rendering skins insoluble in water by combining with them the astringent principle of certain vegetables is a chemical invention, and that without leather our shoes, our carriages, our equipages would be very ill made. You will permit me to say, that the bleaching and dyeing of wool and silk, cotton and flax, are chemical processes ; that the working of iron, copper, tin, and lead, and the other metals, and the combining them in different alloys, by which almost all the instruments necessary for the turner, the joiner, the stonemason, the ship-builder, and the smith are made, are chemical inventions ; even the press could not have existed in any state of perfection without a metallic alloy ; the combining of alkali and sand, and certain clays and flints, together, to form glass and porcelain, is a chemical process ; the colours which the artist employs to frame resemblances of natural objects, or to create combinations more beautiful than ever existed in nature, are derived from chemistry. In short, in every branch of the common and fine arts, in every department of human industry, the influence of this science is felt ; and we see in the fable of Prometheus taking the flame from heaven to animate his man of clay an emblem of the effects of fire in its application to chemical purposes, in creating the activity and almost the life of civil society.

PROPERTIES OF GUNPOWDER.

Upon reference to the relative proportions of ingredients in ancient Gunpowders,—for example, those given by Tartaglia, about three centuries since,—they will be found to yield powder scarcely more powerful than the composition of a squib, and altogether inapplicable to the exigencies of modern warfare. This did not arise from ignorance of better proportions ; but it is conjectured that the guns were then so weak that stronger powder would have destroyed them. No doubt the proper ratio of ingredients to form good Gunpowder can be determined, *à priori*, from a consideration of chemical laws ; yet it is a remarkable fact, that some time before chemistry was thus far advanced, manufacturers had, by dint of mere experience, discovered the best proportions. Modern chemistry, therefore, in this respect, can afford them no aid. The last great improvement in Gunpowder

consists in what is termed "cylinder" charcoal, whereupon the resulting material acquired so much additional strength that the proportion of charges used for ordnance was in consequence reduced nearly one-third.

If Gunpowder, as now prepared, have any fault, it consists in being, for ordinary purposes, rather *too* strong. Were it desirable, its strength, by a trifling change in the manipulation, might be still further increased, without any alteration of the ingredients or their proportions: indeed, Sir William Congreve actually made some Gunpowder in this manner; but it was found to explode on percussion, besides being in other respects highly dangerous.

The enormous force of inflamed Gunpowder depends on the evolution of various gases, the volume of which, when cooled, it is easy enough to determine; but at the moment of their formation they are vastly dilated by heat, so that their actual effective volume and pressure cannot be justly ascertained. It has been pretty correctly found that a cubic inch of Gunpowder is converted by ignition into 250 cubic inches of *permanent* gases, which, according to Dr. Hutton, are increased in volume eight times at the time of their formation by the expansive influence of heat. Assuming these data to be true, and they have been tolerably well verified, confined and ignited Gunpowder will exert, at least, a force of 2000 lbs. on every square inch opposed to its action.

The proportions of the three ingredients now universally adopted in this country in the manufacture of every 100 lbs. of Gunpowder are :

Saltpetre.	.	.	.	.	77½ lbs.
Sulphur .	.	.	.	.	10½ „
Charcoal.	.	.	.	.	16 „
Total					104

The extra 4 lbs. being allowed for waste.

The atomic composition which approaches nearest to that of Gunpowder is, 1 equivalent of nitre, 1 of sulphur, and 3 of carbon, or,

Saltpetre	.	.	.	.	74.6
Sulphur	.	.	.	.	11.9
Charcoal	.	.	.	.	13.5
					100.0

The theory of the combustion of Gunpowder is this: the sulphur accelerates deflagration and supplies heat; the nitre supplies oxygen and nitrogen gases; and the carbon, by its strong affinity for oxygen, promotes the decomposition of the nitre, combining with its oxygen so as to produce carbonic-ac

gas. The sulphur melts at 226° , and under 280° forms a clear liquid of an amber colour, and below 600° it inflames. In the decomposition of Gunpowder by explosion, the sulphur combines with the base of the potash to form a solid residuum, a sulphide of potassium; whilst three equivalents of carbonic acid and one of nitrogen are the gaseous products.

Professor Bunsen, however, has found that the decomposition which occurs in an explosion is by no means so simple as was formerly supposed. Besides the usual products of carbonic acid, carbonic oxide, nitrogen, and sulphide of potassium, Bunsen shows the presence of hydrogen, oxides of nitrogen, cyanide of potassium, sulphydric acid of potassium, sulphate and carbonate of potash, and various other salts.

Mr. Faraday, in a paper read to the Royal Institution, dwells on the great importance of *time* in producing the effects of Gunpowder. Contrasting its action with that of fulminating mercury, or of those more fearfully explosive compounds the chlorides of nitrogen and iodine, Mr. Faraday shows, that if the explosion of Gunpowder were instantaneous, it would be useless for all its present applications. As it is, however, whenever Gunpowder is fired in the chamber of a gun, it does not arrive at the full intensity of its action until the space it occupies has been enlarged by that through which the ball has been propelled during the first moment of ignition. Its expansive force is thus brought down and kept below that which the breech of the gun can bear, whilst an accumulating, safe, and efficient momentum is communicated to the ball, producing the precise effects of gunnery.

This manageable action is contrasted by Faraday with the effect of a morsel of iodide of nitrogen put upon a plate, and exploded by being touched with the extremity of a long stick. The parts immediately in contact with the iodide were shattered, *i. e.* the end of the stick was shivered, and the spot in the plate covered by that substance was drilled as if a bullet had been fired through it; yet no tendency to lift the stick was felt by the hand, whereas the comparatively gradual action of Gunpowder lifts and projects those weaker substances, wadding and shot, which give way before it.*

It has been shrewdly remarked that Gunpowder was invented by a

* See "Invention of Gunpowder," *Things not generally Known*, First Series, p. 209. Few people are aware of the enormous quantity of gunpowder used for military purposes. At the siege of Ciudad Rodrigo, in January 1812, 74,978 lbs. of gunpowder were consumed in thirty hours and a half; at the storming of Badajoz, 228,830 lbs. in 104 hours, and this from the great guns only. At the first and second sieges of San Sebastian 502,110 lbs. were used; and at the siege of Saragossa the French exploded 45,000 lbs. in the mines, and threw 16,000 shells during the bombardment. One day of the war in the Crimea, the Russians in Sebastopol discharged 13,000 rounds of shot and shell, the only result of which — *three men wounded!* — *New Quarterly Review*:

priest, and Printing by a soldier. The manufacture of Gunpowder was also improved by a Bishop of Llandaff, Dr. Watson, who, for his ingenuity, was one day twitted at Court by George III.

When Watson was unanimously elected by the senate to the Professorship of Chemistry, in the University of Cambridge, in 1764, he *knew nothing of chemistry whatever*; but he did not disappoint the confidence that was felt by himself and others in his ardour, application, and quickness of comprehension. With the assistance of an operator, whom he sent for immediately from Paris, and by immuring himself in his laboratory, he, in about fourteen months, was enabled to read his first course of lectures, which were very successful. He was a Fellow of the Royal Society, and contributed many chemical papers to their *Transactions*; he also wrote and published six volumes of *Chemical Essays*, which were long very popular.

ANCIENT SUGAR.

Dioscorides is said to be the first writer who used the word *Saccharum*, or Sugar, which he describes as a sort of concrete honey, found upon canes in India and Arabia Felix: "it is in consistence like salt, and it is brittle between the teeth like salt." Seneca describes it also as concrete cane-juice. Pliny speaks of sugar as brought from Arabia, and better from India. "It is," he says, "honey collected from canes, like a gum, white and brittle between the teeth; the largest is the size of a hazel-nut. It is used in medicine only." Galen, in the second century, describes sugar almost identically with Dioscorides, excepting that he says nothing of its brittleness and resemblance to salt. In the seventh century, however, Paulus Ægineta specifies sugar as "the Indian salt, in colour and form like common salt, but in taste and sweetness like honey." He recommends that a piece be kept in the mouth, to moisten it, during fevers; from which it may be supposed that the sugar then known was in the form of candy.

Thus it appears that sugar was known as early as the Christian era; and that its origin was very imperfectly understood by ancient Greek and Roman writers. It is probable that the white sugar-candy of China, which has been very long celebrated for its excellence, was the Indian salt of the Roman authors.

The historians of the Crusades describe sugar-cane as met with by the Crusaders in Syria; and one of these, Albertus Agensis, about 1108, says that "sweet honeyed reeds," called *Zucra*, were found in great quantity in the meadows about Tripoli, and were sucked by the Crusaders' army. He describes the husbandmen as bruising the plant, when ripe, in mortars, and setting by the strained juice in vessels till it is concreted in the form of snow, or of white salt: this being the oldest mention extant of the process of extracting sugar from the cane; and the same author records in 1110 the cap-

ture by the Crusaders of eleven camels laden with sugar. Other authorities, however, consider sugar to have been cultivated in modern Europe antecedently to the above date, as well as imported by the Venetians, from the Levant : it was certainly imported into Venice as early as 991. The cane is supposed to have been first planted in Valencia. The manufacture, derived originally from China and India, was introduced into the western world by the Spanish and Portuguese.

Refined sugar has been used in England for four centuries ; since we find Margaret Paston (in the celebrated *Paston Letters*) writing to her husband from Norwich thus : " I pray that ye will vouchsafe to send me another sugar-loaf, for my old one is done."

To the honey, grape, manna, and fruit sugars, which were the principal sweets of the ancient world, we now add the cane, maple, beet, maize, and palm sugars. We manufacture sugar also from potatoes, and other substances rich in starch ; from sea-weeds gathered from the shore ; even from saw-dust when an emergency arises ; and we extract it from the milk of our domestic cattle. It has become to us, in consequence, almost a necessary of life. We consume it in millions of tons ; we employ thousands of ships in transporting it. Millions of men spend their lives in cultivating the plants from which it is extracted, and the fiscal duties imposed upon it add largely to the revenue of nearly every established government. It may be said, therefore, to exercise a more direct and extended influence, not only over the social comfort, but over the social condition, of mankind than any other production of the vegetable kingdom, with the exception, perhaps, of cotton alone.—*J. F. W. Johnston, M.A.*

COMPOSITION OF SUGAR.

Every variety of sugar is made up of carbon, hydrogen, and oxygen, in various proportions. The one remark applies, however, to all,—that the carbon and hydrogen exist in the exact proportion to form *water* ; moreover, no variety of sugar contains nitrogen : this latter fact is expressive of the purpose which sugar subserves when taken as an aliment. It is unable to contribute nitrogen to the animal economy ; but it powerfully contributes to the fixation of carbon in the form of fat, besides contributing to the animal temperature by the combustion of another portion of carbon.—*Brandé's Lectures.*

SUGAR MANUFACTURE.

In every case, one object is paramount, the removal of impurities. This is done through the agencies of lime-water and bullock's blood. The real use of lime-water appears to be this,—the lime forms a chemical union with various colouring matters existing in Muscovado sugar, and yields a flocculent precipitable substance, which, being subsequently enveloped

in the albumen of the blood-serum, coagulated by heat, rises to the surface in a scum, and may be removed.

Perhaps no agent is so effectual as the subacetate of lead. Chemists have long been aware of this fact, but they could not separate the excess of subacetate of lead, which is poisonous, without injuring the sugar at the same time. Dr. Scoffern accomplished this result ingeniously and effectively by means of sulphurous-acid gas, which being transmitted through the leaded sugar solution by means of a forcing-pump, every portion of lead is removed. Professor Brande believes the means of extracting the last portions of lead by Dr. Scoffern's process to be infallible, and that they involve no greater amount of difficulty or skill than may be commanded by every sugar manufacturer who chooses to devote adequate attention to the subject.

The vacuum-pan, and other improvements by the Honourable Mr. Howard in the manufacture of sugar, have already been noticed (see page 182). The injurious effect of heat upon sugar might in great measure be prevented. The production of molasses in the rude colonial manufacture is chiefly the result of the high and long-continued heat applied to the cane-juice, and might be almost entirely prevented by the use of vacuum-pans; the product of sugar being thereby greatly increased in quantity, and so far improved in quality as to become almost equal to the refined article. Indeed, it may be said, that no branch of our manufacture depends more directly upon chemical research, and the diffusion and application of chemical knowledge, than the manufacture of sugar.

The root of the Beet contains often as much as a tenth part of its weight of sugar. By squeezing out the juice, or dissolving out the sugar from the sliced root and boiling down the solution, the raw sugar is obtained. It then possesses an unpleasant flavour, derived from the beet-root; but when refined it is scarcely distinguishable from cane sugar.

At an average of 3 tons an acre of sugar and molasses, it requires upwards of 130,000 acres of rich land to produce the sugar yearly consumed in the British Islands!

Formerly, when sugar was much dearer than at present, it was extensively adulterated with an inferior description of sugar made from potato-starch, by the action upon it of dilute sulphuric acid. But this adulteration has, we believe, ceased. Dr. Pereira, on inspecting an extensive manufactory at Stratford in Essex, found that the potato-sugar was used for mixing with brown sugar, and the molasses produced was consumed in an oxalic-acid manufactory. Sugar has also been extracted from diseased potatoes without the disease touching the starch.

Sugar is phosphorescent, when two pieces are rubbed to-

gether in the dark ; when exposed to a high temperature, sugar undergoes decomposition, yielding various gaseous products, and leaving a large proportion of charcoal, on account of which 1-100th of a grain of sugar is capable of imparting colour to an ounce of sulphuric acid.

A detonating sugar has been obtained by means similar to the mode of preparing gun-cotton : when suddenly heated to redness, this sugar explodes like gunpowder.

HOW TO OBTAIN SUGAR FROM RAGS.

A curious and interesting experiment may be made by very slowly adding concentrated sulphuric acid to half its weight of lint, or linen cut into small shreds, tritulating them in a mortar, and leaving the mixture to stand for a few hours ; after which it is to be rubbed up with water, and warmed and filtered. The solution may then be neutralised with chalk, and again filtered. The gummy liquid retains lime, partly in the state of sulphate, and partly in combination with a peculiar acid, composed of the elements of sulphuric with those of the lignine, to which the name Sulpho-lignic Acid is given. If the liquid, previous to neutralisation, be boiled three or four hours, and the water replaced, acid evaporates, and the dextrine becomes entirely changed to grape sugar. Linen rags may by this means be made to furnish more than their own weight of that substance.

SUGAR AND THE TEETH.—TEETH PARASITES.

M. Larez, of France, has proved that sugar, from either cane or beet, is injurious to healthy teeth, either by immediate contact with them or by the gas developed owing to its stoppage in the stomach. If a tooth is macerated in a saturated solution of sugar, it becomes gelatinous, and its enamel opaque, spongy, and easily broken. This modification is due, not to free acid, but to a tendency of sugar to combine with the calcareous basis of the teeth.

Dr. J. H. Bowditch, of the United States, having examined with a microscope matter deposited on the teeth and gums of more than forty individuals, selected from different classes of society, and in every variety of bodily condition, in nearly every case he discovered animal and vegetable parasites in great numbers ; in fact, the only persons whose mouths were found to be entirely free from these parasites cleaned their teeth four times daily, using soap once. Among the various agents applied were tobacco juice and smoke, which do not impair the vitality of the parasites ; nor does chlorine tooth-

wash, pulverised bark, soda, ammonia, &c. Soap, however, pure white soap, destroys the parasites instantly.

It has been asked, in *Notes and Queries*, *Did the Greek surgeons extract teeth?*—to which Mr. George Hayes has replied, that on one of the ornaments found in some ancient buildings in the Crimea is represented a surgeon drawing a tooth from the mouth of one of the barbarian royalties. "This," says Mr. Hayes, "I think establishes the fact that there were then peripatetic, either Egyptian or Greek, dentists, who resorted to distant countries to practise their art." It is believed this is the only representation of a surgical operation to be met with on ancient sculpture.

HOW THE BEE MAKES HONEY.

The honey is formed or naturally deposited in the nectaries of flowers, and is extracted from them by the working bees. They deposit it in their crop or honey-bag, which is an expansion of the gullet (œsophagus), and from this receptacle they disgorge it again when they return to the hive. In the interval, it is probably somewhat altered by admixture with the liquids which are secreted in the mouth and crop of the insect; so that the honey we extract from the hive may not be exactly in the same chemical condition as when it was sucked up by the bee.—*J. F. W. Johnston.*

COMPOSITION OF BELL-METAL.

This consists generally of from five to three of copper to one of tin; all alloys of this kind being technically called *bell-metal*, whatever purpose they may be used for, just as the softer alloys of eight or ten to one are called *gun-metal*, and the harder and more brittle alloy of two to one is called *speculum-metal*. Other metals and alloys have been suggested for bells: as aluminium, pure or alloyed with copper; cast steel, the iron and tin alloy called *union-metal*, and perhaps we may add glass. Now aluminium is about fifty times as dear as copper, even reckoning by bulk, and much more by weight. Steel bells are said to be harsh and disagreeable, and the same is said of union-metal. The sound of glass is very weak. Much has been said of silver in bells; but it is purely a poetical, not a chemical, ingredient of any known bell-metal, and there is no foundation whatever for the vulgar notion that it was used in old bells, nor the least reason to believe that it would do any good: silver has been put into the pot in a bell-foundry in our time without producing any particular effect; and we can determine for ourselves that a silver cup makes a worse bell than a cast-iron saucepan.

Dr. Percy has cast several small bells of different alloys, besides the iron and tin just mentioned. One of iron, 95, and antimony, 5, differs but little from that of iron and tin

of the same proportions, and is clearly not so good as copper and tin. It should be mentioned that antimony is generally considered to produce an analogous effect to tin in alloys, but always to the detriment of the metal in point of tenacity and strength. Again, a bell of copper, 88·65, and phosphorus, 11·35, makes a very hard compound, capable of a fine polish, but more brittle than bell-metal, and inferior in sound even to the iron alloys. Copper, 20·14, and aluminium, 9·86, which makes the aluminium bear about the same proportion in bulk as the tin usually does, seems more promising. This alloy exceeds any bell-metal in strength and toughness, and polishes like gold; and it is superior to every thing except gold and platinum in its resistance to the tarnishing effects of the air. But this alloy will not stand for a moment against the old copper-and-tin alloys for bells. A brass bell is better than the phosphorus and aluminium alloys, though inferior to bell-metal.

M. Deville, of Paris, has cast a bell of aluminium, from a drawing of our great Westminster bell reduced to six inches diameter. He has also turned the surface, which improves the sound of small bells where the small unevennesses of casting bear a sensible proportion to the thickness of the metal. Still the sound exceeds all others in badness.

The question remains, What are the best proportions for the copper and tin alloy, so as to give the strongest, clearest, and best sound possible? They have varied from something less than three to something more than four of copper to one of tin, even disregarding the bad bells of modern times, some of which contain no more than ten per cent of tin instead of from one-fifth to one-fourth, and no less than ten per cent of zinc, lead, and iron adulteration.

From various experiments, it has been found that the best metal for the purpose is that which has the highest specific gravity of all the mixtures of copper and tin. It is clear, however, that the copper now smelted will not carry so much tin as the old copper did, without making the alloy too brittle to be safely used. It has been found that the three-to-one alloy, even melted twice over, had a conchoidal fracture like glass, and was very much more brittle than 22 to 7 twice melted, or 7 to 2 once melted; accordingly the metal used for the Westminster bells is 22 to 7 twice melted; or, reducing it for convenience of comparison to a percentage, the tin is 21·1 of the alloy (not of the copper), and the copper 75·86. This 22 to 7 mixture, or even 3½ to 1, which is probably the best proportion to use for bells made at one melting, is a much "higher" metal, as they call it, than the modern bell-founders, either English or French, generally use. Mr. E. B. Denison, M.A.,

the founder of the Westminster palace clock and peal bells, and the author of the paper whence most of these facts are derived, advises every person who makes a contract for bells to stipulate that they shall be rejected if they are found on analysis to contain less than 22, or, at any rate, 21 per cent of tin, or more than 2 per cent of any thing but copper and tin.

GLASS-MAKING.

Upon no branch of invention have the researches into Egyptian antiquities thrown a stronger light than upon Glass-making. Thus, the discovery of a glass bead, with the name of a Pharaoh of the eighteenth dynasty, proves glass-blowing to have been known upwards of 3200 years ago. Wilkinson found at Beni Hassan two paintings of glass-blowers at work; and from the hieroglyphics accompanying them, they are shown to have been executed 3500 years ago. The use of glass bottles is also shown by far older paintings than the above.

“Glass (says Sir Gardner Wilkinson) was applied to many uses by the Egyptians, who were always celebrated for their skill in its manufacture: natron, or subcarbonate of soda, a native production in different parts of the country, was the very substance most likely to lead to its invention, or rather to its accidental discovery; and it is far more reasonable to suppose that this would have been made where natron abounded than from a fire once accidentally lighted on the sea-shore by some Phœnicians who happened to be carrying a cargo of natron.” (*The Egyptians in the time of the Pharaohs*, p. 86.)

It is a curious fact in the history of discovery, that the manufacture of Glass is unknown at Sidon, in Syria, not far from Belus, where the above accidental discovery is laid. Anciently, however, Sidon was famous for its glass articles.

The claims of glass to be ranked as a strictly chemical combination, illustrated by Faraday, will be found noticed in *Things not generally Known*, First Series, p. 211.

Although perfectly transparent itself, not one of the materials of which glass is made partakes of that quality; a combination, which may, at the period of its invention, have been as astounding as the identity of carbon and the diamond, established by the chemical philosopher of our own time.

The obtaining of achromatic (so as to remedy aberration of colour) flint-glass has long been a difficulty with the scientific maker. Mr. Apsley Pellatt, some years since, constructed a small furnace to try the principle of agitating fused flint-glass by a covered rotating pot, with one or more interior divisions; and this mode of subjecting the glass to a uniform intensity of heat and agitation destroys the striae, or cords, without exposing

the contents to the cooling effects of the atmospheric air. Mr. Pellatt maintains that there would be no difficulty in ensuring good achromatic flint-glass, could the manufacturer anticipate a fair remunerative price and demand, after having succeeded in obtaining the quality. Probably, he could only sell 600 cwt. per annum, were he to supply all the opticians in Great Britain, which, at ten times the price of ordinary flint-glass, would scarcely be remunerative. The quality of optic plate is uncertain; and if unfit for the optician, it becomes valueless to the manufacturer for other purposes. As an affair of science and merit, especially were a Government premium offered for a uniformly certain process, which has not yet been accomplished at home or abroad, it is anticipated that English manufacturers would rival foreigners in this field of honourable competition.

"The manipulatory operations of glass-making are dissimilar to casting metals of any kind. Scarcely any advance in this department of the manufacture has been made for above two hundred years; and the tools then used for blowing and shaping the various articles have been but little improved. There can scarcely be chemically, and in reference to the preparation of the crude materials, a manufacture of greater simplicity, or of easier management, than that of Flint-glass." *

Coke possesses one of the remarkable properties of the diamond—that of *cutting glass* so clean and perfect as to exhibit the most beautiful prismatic colours, owing to the perfection of the incision.

Malleable Glass was made in old Rome; and in the reign of Tiberius, a Roman artist had, according to Pliny, his house demolished—according to other writers, he was beheaded—for making glass malleable. The idea of discovering the secret was only ranked second to that of the Philosopher's Stone among alchemists; but in 1845, there is stated to have been discovered at St. Etienne in France the means of rendering glass as malleable when cold as when first drawn from the pot. The substance silicon is combined with various other substances, and can be obtained opaque or transparent as crystal; it is described as very ductile and malleable, neither air nor acids acting upon it.

Rough Plate-Glass, not transparent, but well adapted for railway-stations and workshops, and for use in horticulture, is now made by a very simple means, patented by Mr. Hartley, of Sunderland. The sole secret consists in ladling rough glass directly on to a hot table near the melting-pot, in place of car-

* See *Curiosities of Glass-making: with Details of the Processes and Productions of Ancient and Modern Ornamental Glass Manufacture*. With coloured strations. By Apsley Pellatt. Small 4to, 1849.

rying it as heretofore out of the refining-pot to a cold table at some distance from the furnace. By this means rough plate-glass is now made in minutes instead of hours, or days; and in patterns stamped by the table, which becomes so hot as to keep the glass molten till stamped, and till one ladleful is added to another and imperceptibly joined to it, so as to form plates of any size. One glass-making firm is stated to have expended 25,000*l.* in vainly endeavouring to use the ladle and to draw the table close to the rough melting-pot!

Soluble Glass and *Water-Glass* are the names given to soluble Silicate of Soda, which, in contact with lime, consolidates, and is partly converted into silicate of lime. Silicate of soda is the substantial element in Ransome's artificial stone process, and other similar processes, in which a porous sandstone or limestone, being saturated with this silicate, not only consolidates, but combines with the lime, forming a compact mass of flinty hardness, and impervious to atmospheric influence. The soluble Silicate has also been employed as a protecting varnish for out-door fresco-paintings in Berlin. Mixed with lime, it forms a good cement for china and glass.

PAINTED AND STAINED GLASS.

Glass is coloured by mixing some metal with the ingredients in the melting-pot. Mysterious recipes, so recently as fifty years ago, were affected for making the coloured pot-metal. Most of the discoveries are said to have been accidentally made. The ancient glass was coloured by using gold in the pot; yet it was by chance discovered, in a German glass-house, that a beautiful red may be procured from copper, and this is now done. The existing mode of blowing ruby glass is thought to be as old as the use of coloured glass in England, which is said to date from the year 647. It has been often said that modern glass-painters cannot produce the rich ruby-red of the ancients; but this is an error: there is no difficulty in its production at the present day; but the cost of the powder (a compound containing much gold) by which it was anciently produced causes the moderns to use less expensive ingredients, except for first-rate work. Protoxide of copper is generally used, and is stated to produce a red equal to the ancient colour. (See *Things not generally Known*, First Series, p. 226.)

Professor Buckman has analysed *tessellæ* from Roman pavement found at Cirencester, and found that on scraping away the verdigris-green of a medallion of Flora, a beautiful ruby glass presented itself. An analysis showed the change from ruby to green to be due to the fact that the ruby glass had derived its colour from peroxide of copper, and that the *tessellæ*

had become covered with carbonate of copper from a decomposition of their surfaces.

Yellow is the only colour that can be applied to glass as a stain upon its surface ; for the colour in the pot-metal and the flashed glass in all other cases enters into actual combination with the melted materials. This yellow stain was unknown before the beginning of the 12th century, about the time of Edward I., and has ever since been much used in preference to the yellow pot-metal. It possesses this great advantage, that while all other colours are diffused over the entire piece of pot-metal glass, yellow can be applied partially, and it is the only stained glass properly so called. Silver was the material employed in this yellow stain : this discovery is attributed to Van Eyck ; but it is ascribed with greater reason to Beato Giacomo da Ulmo.

White glass can be ornamented with a yellow device, and a yellow stain applied to each side of white glass produces a very rich colour. It can also be applied to blue flashed glass, making it green, or to ruby, which it turns into bright scarlet ; so that the yellow stain added greatly to the resources of the ancient glass-painters.—*Abridged from a paper by Mr. G. J. French, F.S.A.*

Cobalt produces so intense a blue that a single grain of the pure oxide will give a deep tint of blue to 240 grains of glass.

The superior colours of ancient glass may be partly the result of age, as well as manufacture or method of painting. "We all know the purifying as well as the bleaching effect of light ; and may we not reasonably suppose that during the lapse of ages the old glass has been permeated and saturated by floods of light, so that the colours have been chastened, purified, and exalted in brilliancy?"—*Painting popularly Explained, by T. J. Gullick, Painter, and John Timbs, F.S.A., p. 141.*

FLAX PROCESSES.

Remarkable modifications in woody fibre have been effected by chemical treatment ; as in the Cottonising processes of Clausen, and the Corrugating processes of Mercer.

On account of the difficulties of working flax in those forms of machinery employed in the manufacture of cotton, M Claussen converts flax, by a chemical process, into a state some thing like that of cotton. This he accomplishes by first steeping the flax in a lixivium of carbonated alkali, and subsequently in a weak acid. Now the combined agencies of these two menstrua are as follow : no sooner does the acid come in contact with the carbonated alkali, previously absorbed by the cotton fibre, than carbonic acid is liberated ; which gas, exercising a

pressure, bursts the filaments of the flax asunder, and reduces the material to a physical condition something like that of cotton.

Mercer's Corrugating process has for its object the strengthening of cotton tissues by corrugation of their fibres. This he accomplishes by the action of caustic alkaline lyes, which deposit their alkali in the state of chemical union with the cotton-cloth, swelling and at the same time corrugating its tissue, whilst the capacity of that tissue for the reception of colours is simultaneously increased.

It is not a little remarkable that the corrugating process should have remained for Mr. Mercer to discover. Ever since the first establishment of the cotton manufacture, a solution of soda has been employed in one stage of the operation of bleaching; but the solution, when employed with this object in view, is used hot, and this circumstance accounts for the long period during which the facts observed by Mr. Mercer, and incorporated into his new process, remained undiscovered.

If cotton be submitted to the action of a *hot* solution of soda, no combination of the alkali with the cotton fibre takes place, but a mere bleaching action results, chiefly dependent on the removal of coloured resinous matter. If, however, the same cotton fibre be subjected to the action of *cold* soda-solution, a very peculiar result ensues. Supposing the alkaline solution poured through the fabric, if the layers of cotton be sufficiently numerous, the whole of the alkali in the solution employed will be removed, and retained in combination with the fabric, imparting to it a peculiar corrugated appearance. The combination, however, is not permanent, since boiling water poured upon the tissue expels the whole of the soda. But the cotton does not return to its original state; for every equivalent of soda expelled, an equivalent of water has been taken into combination, and this combination is permanent. (*Brande's Lectures*, edited by Scoffern.)

Belfast and its neighbourhood is one of our great seats of linen manufacture. Here, in the bleaching-works, may be seen the linen steamed in wooden vats, and alternately immersed in a solution of chloride of lime mixed with carbonate of soda, and of sulphuric acid, many times, during which process the linen is violently beaten about by large wooden arms in a stream of water. It is then rubbed in a machine with a strong soap, in another it is starched; and subsequently, by long-continued thumping with beetles, the peculiar gloss is imparted to the linen.

In the vitriol-works here are prepared not only oil of vitriol, but also the chloride of soda and carbonate of lime, which are used in the bleaching process. The sulphuric acid is made in

enormous leaden chambers or cisterns, where it is concentrated, and the evaporation is completed in a platinum still. Salt, and condensed hydrochloric acid, and coal, chalk, and sulphate of soda, are mixed together to form in the furnaces the "black-cake," from which the alkaline carbonate is extracted. Here also are the retorts for the evolution of chlorine gas, which, passed over lime, forms the bleaching-powder.

At the starch and glue works may be seen meal converted into starch, and rough scraps of hides and hoofs into glue and size.

WET AND DRY ROT.

Wet Rot in timber depends on a real chemical decomposition, referable to the combined agency of air and moisture, exercised at certain temperatures. Dry Rot is attributable to the growth of certain fungi.

Now it had long been known that the decomposition of timber from any cause might be impeded; and in the case of Dry Rot altogether prevented by imbuing the woody fibres with certain mineral solutions, which likewise diminish the inflammability of the timber.

A solution of corrosive sublimate (bichloride of mercury) was commonly employed as a preventive of dry rot even in the last century; but it was reserved for Mr. Kyan to improve and patent this application, after, he states, twenty years' experience. His process is analogous to tanning; but instead of acting with oak-bark on the gelatine of animal matter, he acts with corrosive sublimate on the albumen, one of the approximate principles of vegetable matter. The timber is placed in the solution, and in from seven to fourteen days the process is complete. It is, however, expensive; and although the preservative effects of Kyanising are complete, a less costly method was found in the process of Sir William Burnett, who, instead of bichloride of mercury, employs the less expensive, more fixed, and equally efficacious salt, *chloride of zinc*, which is not only a preservative but a disinfecting agent, and is now commonly employed. It renders timber almost incombustible.

The French journal *Cosmos* states that a simple method has been adopted in the ship-yards of Venice from time immemorial for testing the soundness of the timber. A person applies his fist to the middle of one end of the timber, while another strikes with a mallet on the opposite end. If the wood is sound and of good quality, the blow is very distinctly heard, however long the timber may be. If the wood is disaggregated by decay or otherwise, the sound will be for the most part destroyed.

THE CHEMISTRY OF WINE.

Mülder, the celebrated German chemist, has, in his work with the above title (published in 1858), ably illustrated the chemical knowledge of Wine. The composition, he tells us, differs according as the wine is red or not red. In the last-mentioned no particular colouring matters are found, and only a trace of tannic acid; in the former both are present. Alcohol and water are among the principal ingredients; then sugar, gum, extractive and albuminous matters; then free acids, such as tartaric, racemic, malic, and acetic acid; tartrate of potash, of lime, and of magnesia; sulphate of potash, common salt, and traces of phosphate of lime; also, and especially in cellared wines, substances which impart aroma, as *cenanthic* and acetic ethers, in variable proportions; and other volatile matters. In red wines, and in many others, a little iron; and, according to one statement, some alumina may also be detected. Lastly, the best wines contain a peculiar substance called *Cenanthine*.

Most of the properties of wine depend upon the sugar, alcohol, tartaric acid, and water, which exist together in it; that is, putting aside taste and smell as standards of comparison. The acid of wine appears to be its most constant ingredient, never falling below three grains, and seldom exceeding six grains, per ounce. The alcohol varies from nine per cent in the weaker Moselles and Hocks, to twenty-four per cent in the stronger Ports and Sherries. But the sugar varies most of all: there is none in Clarets, Burgundies, Hocks, and Moselles; in Sherries, from nine to twelve grains in an ounce; in Ports, from sixteen to thirty grains; Madeiras, twenty to sixty; and in Cyprus as much as one hundred grains in an ounce. As a further illustration, the only difference between Port and Sherry is the quantity of sugar contained in the Port.

Next to tartaric acid, the most important is tannic acid, or tannin. It is most abundant in red wines, but Mülder says he found it in all white wines. The *crust* which is thrown down by red wines is mainly owing to the presence of tannic acid, which, combining with the albuminous matters of the wine, forms an insoluble compound.

The preservation of the wine is, in a great measure, to be ascribed to tannic acid; for the albuminous matters, which are always combined with tannic acid in wine, are thus prevented from decomposition, and the principal cause of the wine spoiling is thereby checked. Wines, therefore, which are intended for exportation, or to be long cellared, must not be deprived of too much tannic acid by means of albumen or gelatine.

Most of the saline matters have no great effect upon the taste: potash is the most important, as it saturates a part of the tartaric acid, and remains in a state of solution. But tartrate and phosphate of lime, together with the small amount of common and other salts in the wine,

have no great influence upon its flavour, colour, or smell. As distinctive marks of the genuineness of the wines, they are of the greatest value: this may be seen by comparing the ash of an adulterated with that of a genuine wine of the same kind as that under examination.

Upon the cause of the *bouquet* of wine, first described by Liebig and Pelouze, Professor Mülder says, the so-called fusel oils have shed most light. They are "ethereal oils, a mixture of several liquids in which the solid substances called fatty acids are dissolved: this mixture may be obtained either by distilling large quantities of wine (as in brandy distilleries), or by subjecting the grape-skins, which have already fermented with the juice, to distillation. In this manner substances actually existing in and belonging to the wine were obtained in such abundance as to allow of the mixed bodies being separated, and their individual constituents separately analysed. The result has shown that many of these ingredients may be artificially imitated; and those who adulterate wine have therefore attempted to improve the less aromatic wines by the addition of some odoriferous substance."

Upon these substances, which form the *bouquet*, the real value of wines depends. The substance which gives the vinous odour is the œnanthic ether, a fetid, ethereal liquid, composed of carbon, hydrogen, and oxygen. The acetic ether is most commonly found in aromatic old wines. Professor Mülder traces it to the oxygen of the air dissolved in wine, and existing in the bottles, which changes alcohol into acetic ether. It can decompose œnanthic ether, separate œnanthic acid; and perhaps the acetic acid, assisted by the tartaric acid, etherises a portion of the alcohol. It is well known that acetic ether is formed, after a time, in absolute alcohol in which it did not previously exist. But the alcohol we are treating of here is not absolute, as it is diluted in wine. A decomposition of œnanthic ether by means of the œnanthic acid in wine seems to Professor Mülder, however, not improbable, as in proportion to the formation of acetic and compound ether in old wine will be the diminution of œnanthic ether. The aroma increases, and the disagreeable odour decreases.

The improvement of wines by keeping is thus explained. All wines contain odoriferous substances, necessarily the products of fermentation; but young wine contains such an excess of œnanthic ether as to make it offensive, and cause it to affect the head.

It is not till the wine has been some time in store, and other fragrant ethers have been engendered from œnanthic ether, that the original aroma of the grape-juice reappears, being no longer masked, but having its bouquet increased by other aromatic ingredients. This fundamental fact, that fetid œnanthic ether is first formed, and masks all other aroma, is true not only of ethereal oils which preëxist in grape-juice,

but also of those fragrant ethers which we have treated of above. These are sometimes found in the fusel oils of younger wines, sometimes in those of bad wines. They are found at an early period, though in no very large quantities ; but they cannot impart aroma to wine until the greatest portion of the ænanthic ether is decomposed. Cænanthic ether is generally supposed to occasion the vinous odour ; but the truth is, it spoils the bouquet, and although it gives rise to many of the aromatic ingredients of cellared wine, so long as it predominates in the wine it is by no means fragrant. A thorough knowledge of chemistry is not sufficient to explain every thing which concerns the aroma of wine. It is well known in pharmacy and perfumery that fresh distilled waters have not a pleasant smell, particularly if they are prepared from fresh plants. They obtain the fragrance which characterises them after the lapse of time.

Professor Mûlder treats of the *Diseases of Wine* under five separate heads : First, the turning, which darkens the colour and destroys the flavour : this is caused by decomposition of tartar. Secondly, ropiness, consisting in the formation of a vegetable mucus from the sugar of the wine : tartaric acid is one cause of this corruption also. Thirdly, bitterness, to which Burgundies are peculiarly liable : this is attributed, hypothetically, to the formation of citric ether ; it arises from the sediment, and often disappears of itself ; drawing off the wine in other casks is therefore a remedy ; or young wine may be added. Acidification is a fourth form of disease : in weak wines contact with air at a high temperature will produce it ; carbonated alkali, introduced in time, stops it ; but the colour and flavour are impaired. Mouldiness consists in the production of mould-plants on the surface of the liquor : the admission of air encourages this disease, and the alcohol disappears in the process ; but how the mould is formed science does not yet pretend to say.

Great mistakes are made in judging of wine merely *by its age*. It is the year or vintage, not the mere lapse of time, which stamps the value. Thus, hock of 1811 (the comet year), is more valuable than hock of 1801 ; and claret of 1834, than claret of 1824.

The nobler wines of the Rhine, and many of those of Bordeaux, are distinguished above all others by producing a minimum of after-effect. The quantity of wine consumed on the Rhine by persons of all ages, without perceptible injury to their mental and bodily health, is hardly credible. Gout and calculous diseases are nowhere more rare than in the district of the Rheingau, so highly favoured by nature. In no part of Germany do the apothecaries' establishments bring so low a price as in the rich cities on the Rhine ; for there wine is the universal medicine for the healthy as well as the sick, it is considered as milk for the aged.—*Liebig's Familiar Letters*.

General Science.

SCIENCE OF LORD BACON.

THE following account of Bacon's knowledge of what had been done in his own day, or before it, shows that he was not invariably observant or mindful of the labours of his predecessors. It is a collection of casual remarks by Mr. Spedding, in Mr. Ellis's several prefaces, in the latest edition of Bacon's Works.

Though he paid great attention to astronomy, discussed carefully the methods in which it ought to be studied, constructed for the satisfaction of his own mind an elaborate theory of the heavens, and listened eagerly for the news from the stars brought by Galileo's telescope, he appears to have been utterly ignorant of the discoveries which had just been made by Kepler's calculations. Though he complained in 1623 of the want of compendious methods for facilitating arithmetical computations, especially with regard to the doctrine of Series, and fully recognised the importance of them as an aid to physical inquiries, he does not say a word about Napier's Logarithms, which had been published only nine years before, and reprinted more than once in the interval. He complained that no considerable advance had been made in geometry beyond Euclid, without taking any notice of what had been done by Archimedes and Apollonius. He saw the importance of determining accurately the specific gravities of different substances, and himself attempted to form a table of them by a rude process of his own, without knowing of the more scientific though still imperfect methods previously employed by Archimedes, Ghetaldus, and Porta. He speaks of the *stemma* of Archimedes in a manner which implies that he did not clearly apprehend either the nature of the problem to be solved or the principles upon which the solution depended. In reviewing the progress of mechanics, he makes no mention of Archimedes himself, or of Stevinus, Galileo, Guldinus, or Ghetaldus. He makes no allusion to the theory of equilibrium. He observes that a ball of one pound weight will fall nearly as fast through the air as a ball of two, without alluding to the theory of the acceleration of falling bodies, which had been made known by Galileo more than thirty years before. He proposes an inquiry with regard to the lever,—namely, whether in a balance with arms of different length but equal weight the distance from the fulcrum has any effect upon the inclination, —though the theory of the lever was as well understood in his own time as it is now. In making an experiment of his own to ascertain the cause of the motion of a windmill, he overlooks an obvious circumstance which makes the experiment inconclusive, and an equally obvious variation of the same experiment, which would have shown him that his theory was false. He speaks of the poles of the earth as fixed in a manner which seems to imply that he was not acquainted with the precession of the equinoxes; and in an-

other place, of the north pole being above and the south pole below, as a reason why in our hemisphere the north winds predominate over the south.*

THE QUADRATURE OF THE CIRCLE.

De Morgan, in his able Paper of "Impossible Problems," gives the following on the Quadrature or Squaring of the Circle, which has been a mathematical problem since the days of Euclid, and is not yet solved.

The Arithmetical Quadrature involves the determination of the circumference by a definite arithmetical multiplier which shall be perfectly accurate. Lambert proved that the multiplier must be an interminable decimal fraction. (See Legendre's *Geometry*, and in Brewster's translation of that work.) The arithmeticians have given plenty of approximate multipliers. The last and most accurate was that by Mr. W. Shanks, of Houghton-le-Spring, who gave the requisite multiplier to 607 decimal places, of which 441 were verified by Dr. Rutherford. To give an idea of the power of this multiplier, we must try to master such a supposition as the following:

There are living things on our globe so small that, if due proportion were observed, the corpuscles of their blood would be no more than a millionth of an inch in diameter. Suppose another globelike ours, but so much larger that our great globe itself is but fit to be a corpuscle in the blood of one of its animalcule; and call this the *first* globe above us. Let there be another globe so large that this first globe above us is but a corpuscle in the animalcule of that globe; and call this the *second* globe above us. Go on in this way until we come to the twentieth globe above us. Next, let the minute corpuscle on our globe be another globe like ours, with every thing in proportion; and call this the first globe below us. Take a blood-corpuscle from the animalcule of that globe, and make it the second globe below us. Then, if the inhabitants of the twentieth globe above us were to calculate the circumference of their globe from its diameter by the 607 decimals, their error of length could not be made visible to the inhabitants of the twentieth globe below us, unless their microscopes were relatively very much more powerful than ours.

By *Geometrical Quadrature* is meant the determination of a square equal to the circle, using only Euclid's allowance of means; that is, using only the straight line and circle, as in Euclid's first three postulates. On this matter, James Gregory, in 1668, published an asserted demonstration of the impossibility of the Geometrical Quadrature. The matter is so difficult,

* Quoted in the *Athenæum*.

and the proofs of a negative are so slippery, that he would be a bold man who would be very positive on the point, even though there are trains of reasoning, different from Gregory's, which render it in the highest degree improbable, which are, in fact, all but demonstration themselves, that the Geometrical Quadrature is impossible.

To say that a given problem cannot be solved because two thousand years of trial have not succeeded, is unsafe ; for more powerful means may be invented. But when the question is to solve a problem *with certain given means and no others*, it is not so unsafe to affirm that the problem is insoluble. By hypothesis, we are to use no means except those which have been used for two thousand years ; it becomes exceedingly probable that all which those means can do has been done, in a question which has been tried by hundreds of men of genius, patience, and proved success in other things.

The limitation to Euclid's first three postulates is frequently omitted ; and persons are led to conclude that mathematicians have never shown how to square a circle, than which nothing can be more untrue ; and Mr. de Morgan questions whether the above difficulties would ever have existed, if Euclid's ideas of solid geometry had been as well arranged as his ideas of plane geometry.

Montucla has published a history of the Researches on the Quadrature of the Circle (Paris, 1831), which contains besides the vagaries of the insufficiently informed, an account of the attempts of older days, which ended in useful discovery. In later times, the whole subject has lapsed into burlesque ; the few who have made rational attempts being lost in the crowd who have made absurd misconceptions of the problem. To square the circle has become a by-word, though many do not know the problem under a change of terms ; say the rectification of the circumference.

Strange as it may seem, this problem of the Quadrature of the Circle still engages attention ; and persons are found to believe that they have attained even the Arithmetical Quadrature. It has been stated in foreign newspapers, within these few years, that the British government does offer, and always has offered, a large reward for the solution of this problem. This, we need hardly say, is a complete mistake ; the government never, at any time, offered one farthing for the Quadrature of the Circle.

THE TRUE SOURCE OF MECHANICAL ENERGY.

Professor W. Thompson, in a paper read to the Royal Institution, states that it appears certain, from the most careful

physiological researches, that *a living animal has not the power of originating mechanical energy*; and that all the work done by a living animal in the course of its life, and all the heat that has been emitted from it, together with the heat that would be obtained by burning the combustible matter which has been lost from its body during its life, and by burning its body after death,—make up altogether an exact equivalent to the heat that would be obtained by burning as much food as it has used during its life, and an amount of fuel that would generate as much heat as its body if burned immediately after birth.

PARADOXES OF ROTATORY MOTION.

A German philosopher, Ferrell, has by many experiments been led to the conclusion that the effect of communicating rapid rotatory motion is to diminish weight. By means of a horizontally suspended bar, with a wheel at one end, to which rotatory motion could be given, he showed that when the point of suspension was shifted so as to make the wheel-end the heavier, the horizontality of the bar was restored by communicating rapid motion to the wheel, and so remained as long as the wheel kept turning; but as the speed of rotation diminished, the wheel-end gradually dropped down. Instead of descending perpendicularly, however, it leaned on one side. Professor Powell has exhibited this phenomenon to the Royal Institution, and thus shown that a body rotating is lighter than a body at rest; and thus *a leg of mutton when roasting weighs more than when brought to table*. Prof. Powell also showed that in the Prussian rifles, with cylindrical bullets with conical apices, the directions varied with the amount of charge; when it was low, the missiles deviated to one side. This fact was experimentally illustrated by paper shuttlecocks and cardboard bomerangs, the return of which to the point from which they were propelled is one of the paradoxes of rotatory motion. The Professor's explanation is, that when a body is acted on by two forces in different directions, the resulting motion is a compound of the two.

Prof. Powell believes that the precession of the equinoxes might be accounted for by certain paradoxes of rotatory motion. The star Alpha Draconis was to the ancients the Pole-Star, and was inclined to the earth at an angle of twenty-six degrees, exactly the inclinations of the Pyramids at the time they were built; and these stupendous relics of past ages might thus be regarded as gigantic observatories by which Pharaoh's astronomer-royal regulated his chronometers.

THE REAL WORKING FORCE OF A CLOCK.

Our clocks are driven by means of sinking weights, and our watches by means of the tension of springs. A weight which lies on the ground, an elastic spring which is without tension, can produce no effects ; to obtain which we must first raise the weight or impart tension to the spring, which is accomplished when we wind up our clocks and watches. The man who winds the clock or watch communicates to the weight or to the spring a certain amount of power ; and exactly so much as is thus communicated is gradually given out again during the twenty-four hours, the original force being thus slowly consumed to overcome the friction of the wheels and the resistance which the pendulum encounters from the air. The wheel-work of the clock, therefore, exhibits no working force which was not previously communicated to it, but simply distributes the force given to it uniformly over a long time.—*Prof. Helmholtz.*

FAILURE OF OLD MACHINES.

In all that belongs to the mere motion of machines and engines, representations of which were published in the 16th and 17th centuries, the greatest possible ingenuity and fertility of invention is displayed. But in all that concerns construction, framing, and adaptation of form and dimensions to resistances, strains, and the nature of the work, a total absence of principle and experience is manifested ; so that it is apparent that these machines would act very well in the form of models ; but that, if actually set to work, the most of them would knock themselves to pieces in a very short time.—*R. Willis, F.R.S.*

ECONOMY OF HIGH-PRESSURE STEAM.

It must appear obvious to every reflecting mind that steam generated under pressure, and compressed into one-fifth or one-sixth the space it formerly occupied, and that again applied to an engine of little more than one-third the bulk, must be a desideratum. Let us calculate, for example, the duty performed by, and the force applied to, one of the largest class of locomotive engines, travelling with a train at the rate of forty-five miles an hour, and we shall find the amount of power given out to exceed that of 700 horses, or as much as would be required to drive the machinery in some of our largest factories.

This extraordinary power is exemplified in the process of preparing peat. In Prussia, steam at 60 lbs. pressure is used and passed through pipes to obtain at least 600° of heat, and is then thrown into compressed peat, where it produces the effect of a "fiery sponge," robbing the peat of its water, car-

bonising the material, and effecting the complete distillation of many substances. The texture of the peat is so far changed that it takes fire by exposure to air, so that it is necessary to cool down the charcoal in an atmosphere of steam.

Here may be noticed two predictions of Steam-power which have been singularly verified. In Dr. Darwin's *Botanic Garden*, first published in 1789, but written, it is well known, at least twenty years before the date of its publication, occurs the following prediction respecting steam :

" Soon shall thy arm, unconquered Steam, afar
 Drag the slow barge, or drive the rapid car ;
 Or, on wide-waving wings expanded bear
 The flying chariot through the fields of air.*
 Fair crews triumphant leaning from above,
 Shall wave their fluttering 'kerchiefs as they move ;
 Or warrior bands alarm the gaping crowd,
 And armies shrink beneath the shadowy cloud :
 So mighty Hercules, o'er many a clime
 Waved his huge mace in virtue's cause sublime ;
 Unmeasured strength with early art combined,
 Awed, served, protected, and amazed mankind."

another and less widely known poem by the same author, *The Temple of Nature*, published in 1820, there occurs this complete anticipation and still more remarkable instance of scientific prevision. In a note to line 373, canto ii. of the poem, the author sets out with, "The progressive motion of fish beneath the water is produced principally by the undulation of their tails ;" and after giving the rationale of the process, he goes on to say that "this power seems to be better adapted to push forward a body in the water than the oars of boats ;" concluding with the query : "Might not some machinery resembling the tails of fish be placed behind a boat so as to be moved with greater effect than common oars, by the force of wind or steam ?"

PERKINS' STEAM-GUNS.

• These steam-engines (invented by Mr. Jacob Perkins) excited the greatest attention, in consequence of the notion that the expansive force of steam might be substituted for that of gunpowder in military operations. The principal points in which these Steam-Guns differ from those ordinarily used in warfare are, that, owing to the duration of the propelling force, they enable us to discharge in a short time a great number of balls ; and, in consequence of the facility with which the tube may be turned on a swivel, the shower of balls may be directed in any direction that is desired. But it was found that these engines required complicated and ponderous apparatus, even when their size was only such as fitted them to discharge small shot ; that a considerable time must elapse before the steam attained the necessary force to effect the discharge ; and,

• Darwin projected an "aerial steam-carriage," in which he proposed to use wings similar to those of a bird, to which motion was to be given by a gigantic power worked by high-pressure steam, though the details of his plan were not bodied forth.

lastly, that the force of percussion attained by the balls was less than that of similar balls projected by means of gunpowder. Prechtel has demonstrated that the effect of steam, under those circumstances in which it has yet been found, is not equal to that of gunpowder when applied to large shot.—*Prof. Peschel.*

In 1841, M. Delectuze discovered, among the manuscripts of Leonardo da Vinci, an entry carrying a knowledge of the steam-engine applied to warfare to at least as far back as the fifteenth century. He has published in the *Artiste* a notice of the life of Leonardo, in which he adds a fac-simile of a page of one of his manuscripts, containing five pen-and-ink sketches of details of the apparatus of a Steam-Gun, with an explanatory note on what he designates the “Architonnerre.” The entry is as follows :

Invention of Archimedes. The Architonnerre is a machine of fine copper, which throws balls with a loud report and great force. It is used in the following manner: One-third of the instrument contains a large quantity of charcoal fire. When the water is well heated, a screw at the top of the vessel which contains the water must be made quite tight. On closing the screw above, all the water will escape below, will descend into the heated portion of the instrument, and be immediately converted into a vapour, so abundant and powerful that it is wonderful to see its force, and hear the noise it produces. This machine will carry a ball a talent in weight.

It is worthy of remark that Leonardo da Vinci, far from claiming the merit of this invention for himself, or the men of his time, attributes it to Archimedes.

The Steam-Gun of our time has been an exhibition-room wonder; and the prediction of the Duke of Wellington, that it would fail in warfare, has never been tested.

THE STEAM-HAMMER.

To the genius of James Watt may be traced the first idea of using a hammer in connection with the power of steam, although it was left for one of our own time practically to carry out the project. In Watt's patent of April 28, 1784, he proposes to apply “the power of steam or fire engines to the moving of heavy hammers, or stampers, for forging or stamping iron, copper, and other metals,” without the intervention of rotative motions or wheels, by fixing the hammer either to the piston or piston-rod, or working-beam of the engine.

In 1842, Mr. James Nasmyth patented this gigantic yet manageable machine, which he has constructed for and distributed to all parts of the globe. It is now employed in all the large engineering establishments of Great Britain: by anchor-makers and engine-builders, and railway manufacturers, as well as for making up iron, either from scraps, old rails, hoops,

or from the pile. Before the introduction of this machine to the smithy, the forging of large marine-engine shafts for ocean steamers was not only tedious but uncertain; for without blows of sufficient energy it was impossible to expel the scorise from between the bundles of iron rods to be welded into main-shafts. The Steam-Hammer is likewise employed in stamping out dish-covers and moulding and forming silver-plate.

Steam-Hammers are made of various powers to suit different kinds of work. The anvil is usually below the floor; the hammer is suspended from the piston-rod of the steam-engine, and the piston works in the cylinder placed at the top of the machine. By admitting the steam under the piston, the hammer is elevated to the desired height, and by its own gravity the hammer falls; but the fall may be regulated by the admission of steam. Every degree of blow is attainable, from that of merely cracking an egg-shell to that of a dead pressure of 500 tons. By aid of a powerful crane, a giant may be seen welding and forging a shaft weighing 16 tons, and 27 feet in length, as easily as a country smith would make a horseshoe. Notwithstanding the enormous mass of metal which the hammer contains, and though, at first sight, it resembles a piece of monumental work rather than a tool to be used in the manufacture of machinery, it is beautifully proportioned; it is as manageable as a child's toy, and works as smoothly as the mechanism of a chronometer.

ROMAN ROADS AND BRITISH RAILWAYS.

The formation and repair of Roads in Rome and its provinces were among the most important labours of the Roman emperors. Thus, a continuous roadway existed from the wall of Antoninus in North Britain to Rome, and thence to Jerusalem, a distance of 3655 miles, exclusive of a sea-passage of 85 miles. The Via Appia, one of the twenty-nine roads which diverged from the imperial city, well illustrates the character of the Roman roads. Comparing modern British railroads with these ancient ways, there is a general similarity in the directness of their course, their level surface, and the severance of natural obstacles in order to attain those objects; we have borrowed from the very language of old Rome the *station* and the *terminus*; and in some instances the rails are laid upon the roads of our conquerors. Yet one hundred such works as the great substructure of the Appian Way at Arici would hardly equal, in cubic contents and probable cost, the high-level bridge at Newcastle, the Tweed viaduct at Berwick, and the Britannia and Conway tubular bridges. But, in considering the enormous cost of these modern structures, it should

be remembered that charges for land, law, and parliamentary expenses, were unknown to the Romans ; and our superiority consists more in mental power and scientific knowledge than in the mere application of unskilful labour.

SILVER, GOLD, AND IRON.

So unimportant a part do Silver and Gold seem to perform in the economy of nature, that if they were annihilated it is probable that the world would go on as well without them. How different in these respects from Iron, and how much less, therefore, intrinsically valuable ? Independently of their beauty, the only really valuable properties of Silver and Gold are the difficulty with which they are acted upon by heat and other extraneous agents,—properties which, if they were more abundant, would render them well adapted for a great many useful purposes.—*Proust's Bridgewater Treatise.*

WEAR OF MALLEABLE AND CAST IRON RAILS.

It is a curious and important fact, that not only are Malleable Rails more durable than those made with Cast iron, but that malleable rails, when in use, are less susceptible to the deteriorating influence of the atmosphere than the same rails would be if unused. A bar of wrought iron, if placed upon the ground alongside one of the same form and material in the railway in use, has been made to show this fact in a very striking manner. The former is continually throwing off scales of rust, while the latter continues almost wholly free from waste of that description. This curious fact was discovered by Mr. George Stephenson to depend on certain electric influences, communicated by the passage of the trains.

WHY IRON RAILWAYS DO NOT RUST.

Ritter has proved by experiment that Magnetism has the power of protecting iron from corrosion ; and by this influence the rails in use on railways are protected from rust : both induced and permanent magnetism is thus produced in the rails, each rail being magnetic with polarity, and having from four to eight separate poles.

INVENTION OF THE SAW.

The invention of the Saw has been ascribed by Pliny to Dædalus ; but it has been traced to much higher antiquity—the age of the fourth dynasty of Egypt. In sawing, the Egyptians used a large hand-saw : they frequently fixed the wood upright, secured by pins in lieu of a vice, or with pins passing

through the piece of timber itself, in order to support the planks as they were cut apart; which is the practice of modern sawyers.—*Wilkinson.*

THE FIRST SAW-MILL.

The old mode of making boards was to split up the logs with wedges; and, inconvenient as the practice was, it was no easy matter to persuade the world that the thing could be done in any better way. Saw-mills were first used in Europe in the 15th century; and in the year 1555, an English ambassador, having seen a saw-mill in France, thought it a novelty which deserved a particular description. It is amusing to see how the aversion to labour-saving machinery has always agitated England. A Saw-mill was erected in Lambeth (on the site of Lambeth water-works) in Cromwell's time, and which he protected by Act of Parliament. Another Saw-mill was established by a Dutchman, in 1663; but the public outcry against the new-fangled machine was so violent, that the proprietor was forced to decamp with more expedition than ever did Dutchman before. The evil was thus kept out of England for several years, or rather generations; but in 1768 an unluckily timber merchant, hoping that, after so long a time, the public would be less watchful of its interests, made a rash attempt to construct another mill. The guardians of the public welfare, however, were on the alert, and a conscientious mob at once collected and pulled the mill to pieces!

OAK AND CHESTNUT ROOFS.

Oak is often mistaken for chestnut. At a meeting of the Horticultural Society in 1854, for the purpose of comparison, specimens of the timber of our two English kinds of oak (*Quercus pedunculata* and *Quercus sessiliflora*) and of Spanish chestnut were furnished by the Vice-Secretary, in order to exhibit the difference that exists between the woods of the pedunculate and sessile-flowered oaks and chestnut, for which the timber of the last-named oak, when found in old buildings, has generally been mistaken. It was, however, proved by pieces of wood from Westminster Hall that the timber in the roof of that building is not chestnut, as is still by many believed, but sessile-flowered oak, which, although softer, more pliable, and easily worked, was stated to be in all respects superior to the now more common pedunculate kind. The roof of Westminster Hall was thoroughly repaired in 1820-21, when forty loads of oak, from old ships broken up in Portsmouth Dockyard, were used in renewing decayed parts, and completing the portion at the north end, where it had been left unfinished; the roof was

also greatly strengthened by tension-rods added to the principals in 1851.

ORIGIN OF WOOLWICH ARSENAL.

The Military and Civil branches of the Office of Ordnance have been established at Woolwich since the accession of George I., when a singular train of circumstances led to the fixing on this spot for the naval and military depot, formerly called the Warren, but now the Royal Arsenal.

The original Foundry possessed by the Government for casting brass guns and howitzers was established in Upper Moorfields, London, near the site of the Tabernacle, where John Wesley preached ; and which, from the circumstance of his having before preached beneath a shed in the Foundry itself, was formerly called by that name. The operation of casting the guns was then, as it still is, an object of curiosity ; and many persons, even of the higher ranks, occasionally attended to see the process of running the fluid metal into the moulds.

About the year 1716, when Colonel Armstrong was surveyor-general of the ordnance, it was determined to re-cast the unserviceable cannon which had been taken from the French in the ten successful campaigns of the Great Duke of Marlborough, and which had hitherto been placed in front of the Foundry, and in the adjacent Artillery Ground. Upon the appointed day a great concourse of persons assembled to witness the operation, among whom were many of the nobility, general officers, &c., for whose reception galleries had been prepared near the furnace.

On the same day, a native of Schaffhausen in Switzerland, named Andrew Schalch (who, from a common law of his canton, which made it necessary for every person born there to travel for improvement in his profession during three years, had visited different foundries on the Continent, and at length reached England), was attracted to Moorfields Foundry at an early hour, and was suffered minutely to inspect the work then going on. Colonel Armstrong was himself present, when Schalch, being alarmed at some latent dampness which he had observed in the moulds, addressed him in French, and, after explaining his reasons for believing that an explosion would accompany the casting of the metal, warned him to retire from the impending danger. The Colonel, who at once comprehended the importance of Schalch's remarks, interrogated him with respect to his knowledge of the art, and found him perfectly conversant with all its principles. He therefore resolved to follow his advice, and quitted the Foundry with his own friends, and as many of the company as could be prevailed on to believe that danger really existed. Scarcely had they got to a suf-

ficient distance, when the furnaces were opened, and the metal rushed into the moulds; the moisture of which, as Schalch had intimated, immediately occasioned a dreadful explosion: the water was converted into steam, and this, by its expansive force, caused the burning metal to dart out in every direction, so that part of the roof of the building was blown off, and the galleries fell. Most of the workmen were dreadfully burnt, some lives were lost, and many persons had their limbs broken.

A few days afterwards, an advertisement appeared in the public prints, stating, in substance, that "if the young foreigner who, in a conversation with Colonel Armstrong on the day of the accident at the Foundry in Moorfields, had suggested the probability of an explosion from the state of the moulds, would call on the Colonel at the Tower, the interview might conduce to his advantage." Schalch was informed of this intimation by an acquaintance; and he directly waited on Colonel Armstrong, who told him that "the Board of Ordnance had in contemplation to erect a new Foundry at a distance from the metropolis, and that he was authorised, through the representation which he had made of his conviction of his (Schalch's) ability, to offer him a commission to make choice of any spot within twelve miles of London for the erection of such a building (having proper reference to the extensive nature of the works, and carriage of the heavy materials), and also to engage him as superintendent of the whole concern."

This advantageous proposal was readily accepted by Schalch, who, having inspected various localities, at length fixed on the Warren (previously a rabbit-warren) at Woolwich as the most eligible situation. Here the new Foundry was erected; and the first specimens of ordnance cast by Schalch were so highly approved, that he was fixed in the office of Master Founder, and continued to hold that post for about sixty years, when he retired to Charlton. He died in 1776, when about the age of ninety, and lies buried in Woolwich churchyard. Some of the largest mortars in the Arsenal were cast under his direction, and bear his name. His attention and scientific knowledge were so successfully applied, that not a single accident happened during all the hazardous processes in which he was engaged during his long service. Such was the concatenation of circumstances that gave origin to the Royal Arsenal.

The extension of Woolwich Arsenal in our time has been on a stupendous scale; and in no department of the public service are the vast mechanical resources of the age employed with greater efficiency; yet, amidst its gigantic works, it is impossible to forget—notwithstanding the recent reorganisation of the gun-factories to bring out 1000 colossal guns in a year—the services of the young Schaufhausen engineer, who, a century and

a half ago, by the seasonable combination of talent and opportunity, laid the foundation of the chief war establishment of the most powerful nation in the world.

FAILURE OF "LONG RANGES."

The published accounts of monster guns and enormous mortars may often have led to the question whether there is any reason in the nature of iron and gunpowder why you should not make a cannon as large as the Monument, and discharge a ball of any size to any distance. The answer appears to be, as to the size of the cannon itself, and consequently that of the ball, there is no limit at all, except in the difficulty of casting masses of iron of more than a very moderate thickness without imperfections of various kinds, which would burst the gun when fired with an enormous charge of powder.

The limit of distance to which a ball can be carried is determined by two principles. First, the resistance of the air to the passage of the ball increases more rapidly as the speed of the ball increases than the speed of the ball itself. So that if an enormous initial force were brought to bear on the ball at first starting, it would encounter so immense a resistance that the total result would appear to be inconsiderable. The resistance of the air in arresting the progress of a ball may be inferred from the fact, that a projectile which in our atmosphere ranges little more than two miles, would *in vacuo* have a range of more than sixty.

The other curious principle connected with the subject is that the efficiency of an explosive compound depends rather on its elasticity than its disruptive power. Elasticity is the gradual progressive development of force; and if a compound expends the whole of its force at once, it does not produce any thing like the effect which would follow upon a more gradual evolution of force, though the explosion might be less powerful. Fulminating silver, for example, would be a very bad substitute for gunpowder, even if any cannon could be found which would not burst to atoms on its explosion.

These considerations show, amongst other things, that it is impossible that immensely long ranges should ever be attained by increasing the initial force of a projectile, or by using explosive compounds stronger than gunpowder. Such results can only be obtained either by the principle of the rocket, or by the diminution of the resistance of the air by means of proper alterations in the forms of projectiles. One of the longest shots ever made was, according to Dr. Scoffern, something more than four miles. The projectile used was a shell filled with lead, which was fired from a fifty-six-pound gun.

FLOATING BRICKS.

Bricks which floated on water are mentioned by Posidonius, Strabo, and Vitruvius Pollio as having been made of an aluminous earth found in Spain, for building, on account of their lightness. Pliny also mentions a pumice-like earth possessing these properties. In 1791, Giovanni Fabroni formed floating bricks from a siliceous earth found at Santafore in Tuscany; they were also such bad conductors of heat that they might be held by one end in the hand while the other end was red-hot; and similar bricks have been made from the siliceous earth dug on the borders of the Spree at Berlin; whereas floating bricks were hitherto thought to be "wonders of the ancients."

ANTIQUITY OF STENCIL.

In the *Philosophical Transactions* for 1738, vol. xl. p. 393, we read that Procopius, in his *Historia Arcana*, says, the Emperor Justinus, not being able to write his name, had a thin, smooth piece of board, through which were cut holes in the form of the four letters J. V. S. T., which, laid on the paper, served to direct the point of his pen; his hand was guided by another. Possibly, this may likewise have given the hint to the first of our card-makers, who painted their cards in the same manner, by plates of pewter or copper, or only pasteboard, with slits in them in forms of the figures that are to be painted on the cards. Such is the art of Stencil, which has been applied in our time to decorating the walls of rooms, as well as to the marking of linen.

THE HYDROSTATIC PRESS.

When Pascal, in 1653, was pursuing his experiments on the weight of the air, in order to determine the general conditions of the equilibrium of fluids, he supposed two unequal apertures to be made in a vessel filled with a fluid and closed on all sides. If two pistons are applied to these apertures, and pressed by forces proportional to the area of the apertures, the fluid will remain in *equilibrio*. Having established this truth, Pascal deduced from it the different cases of the equilibrium of fluids, and particularly with solid bodies, compressible and incompressible, when either partly or wholly immersed in them. But the most remarkable part of this discovery, and one which of itself would have immortalised him, is his application of the general principle to the construction of what he calls the *Mechanical Machine for multiplying forces*, an effect which he says may be produced to any extent we choose, as one man may by means of this machine raise a weight of any magnitude. This

new machine is the *Hydrostatic* (or *Hydraulic*) *Press*, first introduced by Mr. Bramah in 1796.—*North British Review*, No. 2.

PNEUMATIC PILE-DRIVING.

This new method, by Potts, consists in sinking, as piles for bridge-piers, tubes by means of the air-pump, the tube or pile sinking as the exhausting process is continued; and the tubes being put down so that their heads are level, to them is fixed a cast-iron plate, on which the pier is built. The tubes have been increased to five and seven feet diameter, when the simple exhausting process not being sufficient to overcome the friction of the sides, another vessel is introduced between the tube and the air-pump; and this being first exhausted, a communication is opened between the tube and the exhausted vessel, when a double effect is produced—the excavating or exhausting process, as in the former instance, with the addition of a sudden blow on the head of the piles.

THE WATER-WORKS AT THE CRYSTAL PALACE, SYDENHAM.

The magnitude of this system of fountains may be conceived from the circumstance, that when the great waters are in full operation, there are 11,788 jets playing, and that the quantity of water simultaneously displayed in them is about 120,000 gallons per minute. The water is supplied from three different elevations, but principally from a reservoir containing about six and a half millions of gallons. The water is in part obtained from an Artesian Well, 575 feet deep, through clay and sand for 360 feet from the surface, and chalk for the remainder.

The water-towers raise a supply of water to such an elevation as to play jets to the height of 250 feet, or 48 feet higher than the London Monument. Each tower consists of 11 stories, and a chimney-shaft surrounded by 6 water columns; and round the chimney is a staircase of 404 steps. The extreme height of the chimney is 276 feet, and the cast-iron cap is 14 feet in height, by 16 feet in diameter. Each tower is strengthened by ten wrought-iron diaphragms, between the columns, tied together by iron rods. The columns communicate with the bottom of the tank, through the centre of which the chimney shafts go: each tank is 38 feet deep, and 47 feet diameter, and will contain 448,000 gallons, or about 2000 tons of water. The total weight on the foundation when the tank is full of water is 3000 tons. Each tower furnishes but one jet of water, the pressure on the square inch at the mouth of the jet being 262 lbs. The engineer of the towers was Mr. I. K. Brunel; and the whole of the works were designed by Sir Joseph Paxton, M.P.

STRENGTH OF PAPER.

In 1837, Mr. Cowper, during a lecture which he delivered before the Society of Arts, produced a quarto sheet of post writing-paper, the ends of which he had pasted together, thus forming an endless web. Into this web he inserted two rods of wood, to one of which was attached a half-hundred weight, and, taking the other in his hands, he raised the weight. With the same sheet, he observed, had been lifted off the ground a man who weighed 150 pounds. With a bank-note, Mr. Cowper also stated, could be lifted 18 pounds.

CIPHER-WRITING.

Mr. Babbage, in a communication to the Council of the Society of Arts, in 1855, offers the following remarks on "the fascinating art of deciphering."

"To contrive a cipher which cannot be deciphered is not a question of importance. To be really useful, the cipher must be capable of being easily and quickly written by the person using it, and as easily and quickly read by the person to whom it is addressed.

"The art of deciphering resembles that of picking locks. The greater number of locks can be picked, and the only question is, what time each requires.

"Mr. Hobbs, during the Exhibition of 1851, picked Braham's challenge lock in about 56 hours.

"The performers in a celebrated robbery of a bank in Scotland spent three months in passing through three locks.

"The last inscrutable cipher I deciphered cost me thirty hours. Some have cost me four or five working days. A cipher deciphered in Paris, for the French Government, occupied its decipherer fully during several months.

"Any intelligent schoolboy can make a cipher which shall cost hours, and even days, for its solution; and it is a fact, that very clever men, who have not studied deciphering, have frequently invented ciphers which nothing (but their solution) could convince them were not inscrutable.

"Under these circumstances, decipherers have an understanding amongst themselves never to examine any challenge cipher unless the proposer has already proved his knowledge of the subject by having deciphered ciphers of admitted difficulty."

THE MANIFOLD LETTER-WRITER ANTICIPATED.

Sir William Petty, in his scheme to establish a Scientific Academy or College (the predecessor of that of the Royal Society), recommends writing to be multiplied by means of an



instrument which he invented, and for which Parliament granted him a patent for seventeen years. He called it his art of double writing, and described the instrument as being of "small bulk and price, easily made, and very durable." This is the prototype of the "Manifold Letter-Writer" of modern times, which has merely accomplished what Sir William Petty effected in 1648. A full account of the invention is given in Ward's *Lives of the Gresham Professors*, p. 218.

WHITWORTH'S DIVIDING MACHINE.

This machine has been exhibited in action by Mr. Whitworth to the Institution of Mechanical Engineers, showing that an advance of $\cdot 000001$ inch ($1\text{-}1,000,000\text{th}$ of an inch) was distinctly indicated by the gravity-piece becoming suspended instead of falling; and the turning back of the divided wheel through two divisions, representing $\cdot 000002$ inch, was then sufficient to cause the gravity-piece to drop, and included consequently all the play in the four bearings of the two screws and two collars. Mr. Whitworth showed also that the fineness of measurement obtained by the machine was sufficient to detect the expansion in length of an inch bar caused by a momentary touch of the finger, the bar then measuring $\cdot 000001$ inch longer than previously (the expansion of iron being about $1\text{-}150,000\text{th}$ of its length for each degree Fahr.; a rise of temperature of $1\text{-}7\text{th}$ of a degree expands an inch bar $1\text{-}1,000,000\text{th}$ of an inch). He stated that in his larger machine for measuring the standard yard, with a bar 36 inches long, the same amount of expansion was shown by the momentary contact of the finger-nail. The finest measurement required the precautions of freedom from dust and moisture in the atmosphere, and from any current of air interfering with uniformity of temperature; and the machine was therefore kept in its glass-case during the time of use, with an opening only sufficient for moving the micrometer wheel and lifting the gravity-piece; by sufficient are in these respects the measure of a space corresponding to half a division on the wheel, or $1\text{-}2,000,000\text{th}$ of an inch, had been rendered distinctly perceptible.

AMERICAN CHRONOMETER.

One of the New York Chronometers supplied to the Grinnell Arctic Expedition, after being subjected to the severest tests, was so exquisitely provided with adjustments and compensations for the very great extremes of temperature to which it had been subjected, that in a polar winter it was returned with a change in its daily rate, during a year and a half, of

only the 18,000th part of one second in that time. The temperature registered during the winter in Wellington Straits was actually 46° below zero.

Horology has enabled us to discover that when the wind passes one mile per hour it is scarcely perceptible; while at the rate of one hundred miles per hour it acquires sufficient force to tear up trees and destroy the produce of the earth. Without the aid of a seconds clock, it would have been scarcely possible to ascertain that a cannon-ball flies at the rate of 600 feet in a second.

GROLIER AND HIS CLOCKS.

At the close of the 16th century (1596), was born at Lyons Nicholas Grollier de Servière, whose career appears to have been a long life of ingenuity. He died in 1689. At the age of fourteen he served in the army in Italy, and lost an eye at the siege of Verceuil. He afterwards served in Flanders, whence he passed into Germany, entered the service of the Emperor Ferdinand, and distinguished himself at the battle of Prague. On his return to France, his knowledge of mathematics and mechanics enabled him to render considerable service to his country in the memorable sieges of the time of Louis XIV.

After many adventures, Grollier retired from the service, and amused himself by inventing and constructing curious clocks, models of floating-bridges, machines for raising water, and wheels for propelling boats, similar in action to the paddle-wheel now used in steam-boats, but worked by manual labour. These models, with various mechanical puzzles, and curious specimens of turning in ivory, formed a cabinet of curiosities at Lyons, a description of which was published by Grollier's grandson.

Mr. Adam Thompson, in his *Time and Time-keepers*, describes several of Grollier's clocks. In one, time was measured by the descent of a ball in a metal groove, twisted round columns supporting a dome: when the ball finished its descent, its weight, lifting a detent, discharged the wheel-work, giving motion to an Archimedean screw, which raised the ball to its former position, again to descend as before.

In another clock, the ball descended in diagonal lines on an inclined plane, the means of ascent in this case being hidden from the observer.

In the third clock, the ball was made to traverse within the bodies of two serpents, which, by a reciprocating motion, were made to swallow the ball alternately. A compound of the motions in the two last clocks (says Mr. Thompson) was adopted

by a scientific gentleman about fifty years since ; and time-pieces on this principle are called Congreve clocks.

Grollier made some of his clocks go by their own weight, descending inclined planes, and others in grooves, forming a path from the ceiling to the floor. When the clock had nearly finished its descent, it was lifted off, and again placed at the highest point of its path ; when the clock was lifted, the hands were set to the proper time before it was again replaced.

Several clocks upon this principle have since been projected, some as novelties, and others for the purpose of avoiding the casualties to which main-springs and weight-lines are liable. A curiosity of this kind, made by Maurice Wheeler, was exhibited in Don Saltero's collection at Chelsea. The Marquis of Worcester is said to have invented another. And one invented by M. de Gennes indicated time by its *ascent* on an inclined plane ; but this machine, as may be supposed, had a spring for its maintaining power. The clock was kept in equilibrium by a weight at the end of a lever ; the unwinding of the springs made the weight change its position, thus changing the centre of gravity, and causing the clock to ascend the plane.

Various methods have been devised to supersede the going-weight and main-spring, and to renew with facility the maintaining power. One time-piece of this sort hung like a lamp from the ceiling, and was kept going by its own weight in descending. To renew the maintaining power (to wind it up), it was only necessary to raise or push it towards the ceiling, when it would continue to go as before.

Among other methods of showing time, Grollier contrived the following clocks to surprise his visitors. A small figure of a tortoise, dropped into a pewter plate filled with water, having the hours marked on the flat edge, would float round, and stop at the proper hour : if moved, it would again return ; and if the tail were placed at the hour, it would turn round, and again point with the head.

A lizard was seen ascending a pillar on which the hours were marked, and pointing to the time as the day advanced.

The figure of a mouse was also made to move on a cornice, and point to the hours marked upon it. These (says Mr. Thompson) were simple contrivances, requiring but a little address to give a hidden motion to a magnet : the intervening substances between it and the figure being thin, the attraction was sufficiently strong.

Scarcely any of Grollier's ingenious works now remain.

INVENTION OF THE SMOKE-JACK.

Heated air has been turned "to sundry pleasant uses, as for the moving of sails in a chimney-corner, the motion of

which sails may be applied to the turning of spits, or the like." Thus writes Bishop Wilkins, adding: "But there is a better invention to this purpose, mentioned by Cardan, whereby a spit may be turned (without the help of weights) by the motion of the air that ascends the chimney; and it may be useful for the roasting of many or great joints: for as the fire must be increased according to the quantity of meat, so the force of the instrument may be augmented proportionably to the fire. In which contrivance there are these conveniences above the jacks of ordinary use: 1. It makes little or no noise in the motion. 2. It needs no winding up, but will constantly move of itself, while there is any fire to rarefy the air. 3. It is much cheaper than the other instruments that are commonly used to this purpose; there being required unto it only a pair of sails, which must be placed in that part of the chimney where it begins to be straitened; and one wheel, to the axis of which the spit-line must be fastened. (Here we have the ordinary Smoke-jack.)

"The motions of these sails may likewise be serviceable for sundry other purposes besides the turning of a spit: for the chiming of bells, or other musical devices; there cannot be any more pleasant contrivance for continual and cheap music. It may be useful also for the reeling of yarn, the rocking of a cradle, with divers the like domestic occasions."—*Mathematical Magic*, book ii.

The Bishop adds that Ctesibius made by this kind of motion his representations of living creatures, whether birds or beasts.

ANCHORS, ANCIENT AND MODERN.

The invention of the Anchor has been ascribed by some to the Tyrrhenians, by others to Midas, the son of Gordius, whose anchor, Pausanias tells us, was preserved till his days in one of Jupiter's temples.* The most ancient anchors were of stone, and sometimes of wood, to which a quantity of lead was fixed. Buckets full of stones and sacks full of sand were employed for the same use. These were let down by cords into the sea, and by their weight stayed the course of the ship. Afterwards, Anchors were made of iron, and furnished with

* The anchor is mentioned at the opening and the close of the sixth Æneid of Virgil. Thus Æneas having reached the Cumæan shore,

"tum c'ente tenâci

Ancora fundabat naves."

("Their anchors dropp'd, his crew the vessels moor." *Dryden*.)

And the final line—

"Ancora de prorâ jacitur, stant litore puppes."

("At length on oozy ground his galleys moor;
Their heads are turned to sea, their stems to shore." *Dryden*.)

teeth or flukes, at first one only : a second was added by Eupalamus or Anarcharsis, the Scythian philosopher. The anchors with two flukes, from ancient monuments, appear to have resembled those used in our days, except that the transverse piece of wood is wanting in all of them. Every ship had several anchors, the largest of which was termed *sacra*, and was never used but in extreme danger ; whence *sacram anchoram solvere* is proverbially applied to such as are driven to their last refuge.

The ancients had anchors even in the time of Archimedes. The great galley of Hiero had four wooden and eight iron anchors. In the ship on board which St. Paul was a prisoner (described in the Acts), the sailors dropped four anchors from the stern, which, however opposed to modern usage, was undoubtedly the ancient method of letting the anchor fall at that period.

The Chinese, who may be supposed to adhere to ancient forms, are said to use chiefly crooked pieces of wood.

The improvement of the Anchor in modern time has received great attention from British manufacturers. In a grand trial of "Anchors of all Nations," made at the Royal Dockyard, Sheerness, Trotman's improved Norton's anchor, on the swivel principle, was shown to possess very considerably more holding property than any other anchor. In this improved anchor the arms or flukes are forged wholly independent of the shank, but are bolted to a pivot or fulcrum at the end, round which the flukes freely move, thus departing at once from the rigidity usual in the construction of anchors. The joint resembles that which connects the wires of an umbrella with the ribs, so that the flukes move round the pin or bolt as an axis ; and when one fluke enters the ground, the other necessarily falls down upon the shank, thereby avoiding the danger incident to the upward projection of a sharp point. By this means is avoided "fouling," by the cable passing over the exposed fluke when the vessel is swinging in a tide-way, or injury in the event of the vessel falling upon her anchor. Of this kind is the large anchor of the *Great Eastern* steam-ship, which was manufactured at the Chester Works, Liverpool. This anchor weighs 6 tons 19 cwt. 2 qrs., and being of Trotman's patent, is equal to an ordinary anchor of 10 tons. The largest anchor used in the British navy is 4½ to 5 tons, of the ordinary kind, and costing about 300*l*.

THE MAGIC WHIRLPOOL.

The singular property of camphor to rotate upon the surface of water is illustrated in the following experiments, bridged from the *Magazine of Popular Science*, vol. iii.

Fill a glass tumbler with water, throw upon its surface a few shavings of camphor, and they will instantly begin to move and acquire a motion both progressive and rotatory, which will continue for a considerable time. During these rotations, if the water be touched by any substance at all greasy, the floating particles will forcibly dart back, and, as if by a stroke of magic, be instantly deprived of their motion.

If the water be made hot, the motion of the camphor will be more rapid than in cold water, but will cease in proportionally less time. Thus, provide two glasses, one containing water at 58 degrees and the other at 210 degrees; place raspings of camphor upon each at the same time. The camphor in the first glass will rotate for about five hours, until all but a very minute portion has evaporated; but the rotation of the camphor in the hot water will last only nineteen minutes; about half the camphor will pass off, and the remaining pieces, instead of being dull, white, and opaque, will be vitreous and transparent, and evidently soaked with water. The gyrations, too, which at first will be very rapid, will gradually decline in velocity, until they become quite sluggish.

The stilling influence of oil upon waves has become proverbial: * the extraordinary manner in which a small quantity of oil instantly spreads over a very large surface of troubled water, and the stealthy manner in which even a rough wind glides over it, must have excited the admiration of all who have witnessed it.

By the same principle, a drop of oil may be made to stop the motion of the camphor as follows; throw some camphor, both in slices and in small particles, upon the surface of water, and while they are rotating, dip a glass rod into oil of turpentine, and allow a single drop thereof to trickle down the inner side of the glass to the surface of the water: the camphor will instantly dart to the opposite point of the liquid surface, and cease to rotate. If a piece of hard tallow or lard be employed, the motion of the camphor will be more slowly stopped than by oil or fluid grease, as the latter spreads over the surface of the water with greater rapidity.

If a few drops of sulphuric or muriatic acid be let fall into the water, they will gradually stop the motion of the camphor; but if camphor be dropped into nitric acid diluted with its own bulk of water, it will rotate rapidly for a few seconds, and then stop.

If a piece of the rotating camphor be attentively examined with a lens, the currents of the water can be well distinguished, jetting out chiefly from the corners of the camphor, and bearing it round with irregular force.

The currents, as given out by the camphor, may also be seen by means of the microscope; a drop or two of pure water being placed upon a slip of glass, with a particle of camphor floating upon it. By this means the currents may be detected, and it will be seen that they cause the rotations.

Or a flat watch-glass, called a *lunar*, may be employed, raised a few inches, and supported on a wire ring kept steady by thrusting one end into an upright piece of wood like a retort-stand. Then put the camphor and water in the watch-glass, and place under the frame a sheet of white paper, so that it may receive the shadow of the glass, camphor, &c., to be cast by a steady light placed above, and somewhat on one side of the watch-glass. On observing the shadow, which may be considered a magnified representation of the object itself, the rotations and currents can be distinguished.

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* See *Things not generally Known*, First Series, p. 26.

BLAZE-PROOF DRESSES.

The frequent accidents of ladies' dresses taking fire teach a lesson which must not be neglected ; for nothing can be more simple than to render the fabrics of which dresses are made blaze-proof. The most delicate white cambric handkerchief, or fleecy gauze, or the finest lace, may, by simply soaking it in a weak solution of chloride of zinc, be so protected that if held in the flame of a candle it may be reduced to tinder without blazing.

Messrs. Versmann and Oppenheim, in a paper read before the British Association, show that sulphate of ammonia and tungstate of soda have the property of making linen and cotton fabrics unflammable, and do not injure or discolour them in washing. Preparations of these salts are used in the Royal Laundry ; and their general adoption would prevent a vast number of those dreadful accidents which now almost daily occur to children and others. MM. Doebereiner and Alsner, after discussing the merits of borax, alum, and soluble glass, for diminishing the combustibility of cotton tissues, recommend phosphate of ammonia, which is cheap, and can be easily combined with sal ammoniac, and introduced into the starch with which the tissues are prepared.

THE INVISIBLE DESPATCH.

Writing with rice-water, to be rendered visible by the application of iodine, was practised successfully in the correspondence with Jellalabad, in our last war with Afghanistan. The first letter of this kind was concealed in a quill. On opening it, a small paper was unfolded, on which appeared only the simple word "iodine." The magic liquid was applied, and therewith appeared an important despatch from Sir Robert Sale.

CURIOUS TRANSMUTATION.

It is perhaps difficult to believe that the same salt (common salt) should be a chloride of sodium in the hand and a muriate of soda in the mouth ; but it is nevertheless true ; nor is it more incredible than the change which sulphuret of potash undergoes by solution, the decomposition of which is rendered evident to the senses by the evolved sulphuretted hydrogen.—*Dr. Paris.*

ANNIHILATION OF THE SMELL OF MUSK.

Some years ago, the emulsion of bitter almonds was found to possess the property of annihilating the smell of musk, and most of the cyanic preparations evince the same power. According to M. Mertot, a druggist of Bayeux in Normandy, ergot of

rye will produce the same effect. This he learned by having to prepare a number of pills containing both musk and ergot, when no sooner were the two substances mixed than the smell completely went off.

BOILING CHECKS FERMENTATION.

M. Renault, Director of the Veterinary School of Alfort, France, has shown that the baking and roasting of meats, and the boiling of liquids arising from animals affected with contagious diseases, have the effect of completely annihilating the virulent properties of these substances. The practical value of this fact will be appreciated by many of the inhabitants of large cities, who are obliged to use milk and some other articles of food which are not of the best quality.

DIRTY WINDOWS.

Every one has observed upon dirty windows in the metropolis small tree-like crystallisations : these consist of sulphate of ammonia, which is produced in the atmosphere by the burning of vast quantities of coal, combining with the sulphurous acid in the air.

THE CHEMISTRY OF MORTAR.

When limestone is burnt, the carbonic-acid gas is expelled from it, and there remains nothing but a pure alkaline earth. Then, if water be mixed with it, as in making mortar, the lime re-absorbs carbonic acid, acquires hardness, and again becomes limestone.

TO COVER LACE OR NET WITH COPPER.

This beautiful experiment can be performed by any person in possession of a simple galvanic battery. First, make a saturated solution of sulphate of copper in a vessel large enough to contain the net or lace that is to be experimented upon fully stretched out. Next stretch the net or lace upon a copper ring ; then dust it well over with the best black-lead, using a camel-hair brush to rub it into every part. This black-lead acts as a conductor to the electricity, when the net is attached to the battery. In fixing the apparatus the ring and net are to be attached to the wire in connection with the zinc end of the battery, and then perfectly immersed in the copper solution. A piece of copper attached to the wire in connection with the copper end of the battery must also be inserted in the decomposing vessel facing the net, not touching it ; this not only acts as a conductor, but also maintains the solution of copper of a permanent strength. In a short time the copper will be found to creep over the whole surface of the net. If

desired, it may afterwards be gilt or silvered by the same process, provided that gold or silver be substituted where copper was previously used. We have little doubt that this experiment will eventually be of great service to commerce and the arts.—*Mining Journal*.

HEAT OF THE VAPOUR-BATH.

The late Baron Alderson, in a letter to his son, says: "I have been obliged at last to send for Sir Benjamin Brodie, to see me for my sciatica, and to-day, by his order, I have been stewed alive in a vapour-bath. Dreadfully hot, I can tell you—140 degrees, while a hot bath is only 98 degrees. Yet it was not unpleasant, after all: for hot air does not burn like hot water, as it communicates its heat gradually to you, air being what they call a bad conductor of heat. So, by the time the hot air makes you warm, a perspiration breaks out and cools you again. People have been known to bear 400 degrees of heat, without much inconvenience. Sir Francis Chantrey told me once he had gone into the oven where he baked his moulds, which is heated by a nearly red-hot plate at the bottom. He wore thick wooden shoes to protect his feet, and a flannel dress, and was able to bear it very well. That was a dead heat that would have baked a pie, and yet a man alive would not be heated much above blood-heat, or about 100 degrees. Is not this curious? Life is able, you see, to bear heat which would roast a dead body."

DROWSINESS FROM COLD.

Very striking and curious is the story of Dr. Solander's escape, when in company with Sir Joseph Banks among the hills of Terra del Fuego. They had walked a considerable way through swamps, when the weather became suddenly gloomy and cold, fierce blasts of wind driving the snow before it. Finding it impossible to reach the ships before night, they resolved to push on through another swamp into the shelter of a wood, where they might kindle a fire. Dr. Solander, well experienced in the effects of cold, addressed the men, and conjured them not to give way to sleepiness, but at all costs to keep in motion. "Whoever sits down," says he, "will sleep; and whoever sleeps will wake no more." Thus admonished and alarmed, they set forth once more; but in a little while the cold became so intense as to produce the most oppressive drowsiness. Dr. Solander was the first who found the inclination to sleep—against which he had warned the others so emphatically—too irresistible for him, and he insisted on being suffered to lie down. In vain Banks entreated and remon-

strated; down he lay upon the snow, and it was with much difficulty that his friend kept him from sleeping. One of the black servants began to linger in the same manner. When told that if he did not go on he would inevitably be frozen to death, he answered that he desired nothing more than to lie down and die. Solander declared himself willing to go on, but said he must first take some sleep. It was impossible to carry these men, and they were therefore both suffered to lie down, and in a few minutes were in a profound sleep. Soon after, some of those who had been sent forward to kindle a fire returned with the welcome news that a fire awaited them a quarter of a mile off. Banks then happily succeeded in awaking Solander, who, although he had not been asleep five minutes, had almost lost the use of his limbs, and the flesh was so shrunk that the shoes fell from his feet. He consented to go forward with such assistance as could be given; but no attempts to rouse the black servant were successful, and he, with another black, died there. —*Fraser's Magazine*.

DOMESTIC HYGROMETER.

Mr. Smee, in his work on *Debility and Defective Nutrition* (the substance of his Hunterian Oration), dwells much on the importance of Fresh Air, saying, "It used to be the fashion to say that all airs were chemically the same; the discovery of ozone, and the effect of air upon the permagnate of potash, lately discovered by Dr. Angus Smith, sufficiently dispels this fallacy. The hygrometric state of the air, as to its wetness and dryness, is of consequence." Mr. Smee then describes a household instrument, of his contrivance, which will show by inspection, with sufficient accuracy, the state of any room, bed, or other situation. This instrument consists of vegetable parchment, invented by Mr. Gaines, and perfected by Mr. De la Rue. It is made by immersing blotting-paper in sulphuric acid of definite strength, by which it is immediately converted into a new material, named by Mr. Smee Ametastine, because it is highly unchangeable by chemical agents. This curious material contracts in a dry and expands in a moist atmosphere. By taking advantage of this property, Mr. Smee has constructed many forms of hygrometers, the most simple of which he expects will be the concomitant of the thermometer in every home, and prevent many a traveller from catching a severe rheumatism in a damp bed.

A Chapter on Chloroform.

THE use of *Anæsthetics*, or substances for producing temporary insensibility to pain, appears to have been known and practised for ages before the organic chemistry of our own times enabled us to place pain completely under the dominion of the human will, by the discovery and use of Chloroform.

We learn from Dioscorides that eighteen centuries ago the root of the Mandrake steeped in wine was given "to cause insensibility to pain in those who are to be cut or cauterised; for, being thrown into a deep sleep, they do not perceive pain." According to Pliny, the juice of the mandrake was given for injuries inflicted by serpents, and before incisions or punctures were made in the body, "in order to ensure insensibility to pain." Indeed, for this last purpose, with some persons, the odour of it is quite sufficient to induce sleep.* Apuleius makes a similar statement as to the mandrake: "If any one is to have a limb mutilated, burnt, or sawn, he may drink half an ounce with wine, and whilst he sleeps the member may be cut off without any sense of pain."†

M. Stanislaus Julien has discovered that the Chinese, in the third century of our era, were in possession of an anæsthetic agent which they employed in the same manner as we use Chloroform and Ether for producing insensibility during surgical operations. In a biographical notice of Hoa-tho—who flourished under the dynasty of Wei, between the years 220 and 230 of our era—it is stated that *he gave to the sick a preparation of Chanvre (Ma-yo), who in a few moments became as insensible as one plunged in drunkenness or deprived of life*: then, according to the case, he made incisions, amputations, and the like. After a certain number of days, the patient found himself reëstablished without having experienced during the operation the slightest pain. It appears from the biography of Hân that this chanvre was prepared by boiling and distillation. This anæsthetic agent of the Chinese is set down as the Indian Hemp, which is taken even now by the Arabs to produce an agreeable drunkenness.

In a work on surgery by Theodric, who lived in the latter half of the thirteenth century, is mentioned "a flavour for performing surgical operations," made of opium, mulberry, hen-

* *Natural History*, book xxv. ch. 74.

† *De Herbarum Virtutibus*, ch. 131.

bane (*hyoscyamus*), hemlock (*cicuta*), mandrake, wood-ivy, lettuce, to be boiled until concentrated in a sponge, which, when wanted, is to be warmed, and "applied to the nostrils of him who is to be operated on, until he has fallen asleep; and so let the surgery be performed."

Bulleyn, in 1579, describes "the possibility of setting patients into an anæsthetic state during lithotomy, &c.," by the use of mandrake; and Baptista Porta, in his *Natural Magic*, gives various recipes for medicines which produce sleep instantly, &c.; among which is the sleeping apple, made with mandrake, opium, &c., the smelling of which binds the eyes with a deep sleep. Now the mandrake, which figures so prominently in all these accounts, has long been a marvel;* but seeing that it belongs to the same genus as belladonna, which has a greater power of annulling sensibility than any plant in present use, unless it be aconite, it is not unlikely to possess the anæsthetic quality ascribed to it—at least to such an extent as to justify us in believing that surgical operations have been performed under its influence without conscious pain.†

The Greeks and Romans were acquainted with the narcotic and anæsthetic properties of Indian Hemp, just mentioned as employed by the Chinese. Herodotus describes the Scythians as inhaling the fumes of hemp-seed thrown upon red-hot stones; and Dr. Royle suggests that Indian Hemp may have been the assuager of grief, the *Nepenthe* of Homer, given by Helen to Telemachus in the house of Menelaus, stated to have been brought from Egyptian Thebes. Now Indian Hemp grows in Africa, and the *bang* prepared from it is taken by criminals who are condemned to suffer amputation; and Sir Joseph Banks tells us that "it is said to enable those miserales to bear the rough operations of an unfeeling executioner more than we Europeans can the keen knife of our most skilful surgeon." Dr. Daniel states that the Indian Hemp is smoked by the natives of Congo, Angola, and South Africa; the leaves, seeds, and flowers, called *Kief*, are used, pounded and mixed with a confection, a piece of which as large as a walnut will deprive a man of reason, and produce the most voluptuous sensations.

In India the hemp is equally celebrated; but the Hindoos do not appear to have ever used it as an anæsthetic during surgical operations. It has been found by Dr. Christison to produce a pleasant numbness, and to render touch and feeling gradually obtuse; so that the practice of anæsthesia, by means of Indian Hemp is credible.

* See *Things not generally Known*, First Series, p. 102; *Popular Errors Explained*, p. 153.

† Dr. Chapman; *Westminster Review*, January 1850.

In 1784, Lassard, surgeon to the Hôpital de la Charité at Paris, recommended the employment of a narcotic previous to painful operations; and in 1782, Augustus, King of Poland, was surreptitiously narcotised by his favourite surgeon, Weiss, a pupil of Petit, at Paris, while a mortified part of his foot was cut off without pain or consciousness. In Guyot's *Causes Célèbres* it is told how the Countess St. Gerau, after nine hours' labour, was made to drink a potion, "which rendered her insensible till the following morning;" meanwhile the child was born, and surreptitiously conveyed away, its very existence being denied to her; but many years after it was, in a French court of law, proved to be her offspring.

Two centuries ago, Middleton, in his tragedy of *Women beware of Women*, published in 1657, thus directly alludes to the practice of anæsthesia in olden surgery:

I'll imitate the pities of old surgeons
To this lost limb, who, ere they show their art,
Cast one asleep, then cut the diseased part.

Mesmerism has been employed as an anæsthetic agent in India, America, France, and England, with success; but its effectiveness is by no means uniform, as it succeeds much better with Orientals than Europeans. Only from the science of chemistry were the seekers after a perfect anæsthetic agent guided in the true direction. To the Pneumatic Chemistry of Black, Priestley, Cavendish, and Lavoisier (see *ante*, pp. 64-66 and 100, 101), succeeded the hope that by means of the inhalation of various kinds of gases, or by the practice of *Pneumatic Medicine*, as the new system was called, many maladies would become amenable to the power of the physician. A medical Pneumatic Institution was set up at Clifton, near Bristol, by Dr. Beddoes; and in 1799, Humphry Davy, who had just completed his apprenticeship, was appointed its superintendent. In a previous page (84) we have recorded how Davy breathed nitrous oxide, which he found to lessen the pain of cutting a wisdom-tooth; and although he did not succeed in establishing nitrous oxide as a medicinal agent, in describing the effects of this gas, he predicts, that, "as nitrous oxide, in its extensive operation, seems capable of destroying physical pain, it may probably be used with advantage during surgical operations in which no great effusion of blood takes place."* Nor was this an accidental conception of genius, but the result of ten months' experiments; so that Davy must be acknowledged as the originator of that prolific idea which has become one of the most glorious realities of the present century.† Davy also foretold that Pneumatic Chemistry, in its application, was an art in its infancy; and had his prophecy and precepts then been heeded,

* Davy's *Collected Works*, vol. iii. † *Westminster Review*, Jan. 1859.

“it is probable that pain would have been put into subjection to the intellect at the very beginning of this century.”

Forty years had elapsed after Davy's announcement, when (in 1844) Horace Wells, a surgeon-dentist, of Hartford, Connecticut, United States, was present at a lecture at which, it is presumed, the effects of inhaling nitrous oxide were shown. Mr. Wells induced the lecturer to accompany him home, and let him (Wells) inhale the gas, while another dentist, Dr. Rigg, drew one of his teeth, without pain; and Mr. Wells, after recovering from the inhalation, exclaimed, “A new era in tooth-drawing!” He then made other experiments with various success; but a failure so annoyed him that he gave up practice as a dentist, became unsettled, came to England, returned to America, and at length died by his own hand, in January 1848. Within three months of this sad end of the discoverer, Dr. Bigelow, of Boston, U.S., removed a breast from a patient who had been rendered insensible by inhaling nitrous oxide, which induced the Doctor to predict: “Nitrous oxide is quite likely to prove a certain as well as a safe and agreeable anæsthetic agent.”

Mr. G. T. Morton, Wells's pupil and partner, and Dr. Jackson, next took up the idea: Morton learned from Jackson the use of chloric ether as a local application; and since 1818* it had been known that the vapour of ether, if inhaled, would produce effects similar to those of nitrous oxide. After several attempts, Morton, on Sept. 30, 1846, by the inhalation of ether, made himself completely unconscious during eight minutes; in the evening he persuaded a patient to inhale ether from a handkerchief, and then extracted a bicuspid tooth, of which the patient knew nothing till he recovered his senses, and saw the tooth lying on the floor. He repeated his experiments on tooth-drawing under the influence of ether in several cases. Emboldened by success, he administered his remedy to a patient in the Massachusetts General Hospital, who was operated on while under its influence. The next day a large fatty tumour was removed from the arm of a patient under the same conditions. Both cases being successful, the remedy was afterwards frequently used.

Meanwhile, a few of the American medical journals condemned the discovery as quackery; but the English journals at once rightly appreciated it. However, in November 1846, the Paris surgeons received the announcement with all but indifference; and Velpeau declined to test its worth. In London it obtained a more speedy trial. Early in December, Dr. Boott

* In 1818, in a paper in the *Quarterly Journal of Science and Arts*, believed to have been written by Mr. Faraday, is described the great resemblance between the effects of the vapour of ether and those of nitrous-oxide gas.

received from Dr. Bigelow instances of the success of "the new anodyne process;" and on Dec. 9 a lady was etherised at Dr. Boott's house, and had a tooth extracted without pain. Mr. Liston, at University College Hospital, on Dec. 21, "amputated a thigh, and removed by evulsion *both sides* of the great toe-nail, without the patient being aware of what was doing, so far as regards pain:" he heard what was said, and was conscious, but felt neither the pain of the incisions nor that of tying the vessels. Next, a patient in the Royal Infirmary, Edinburgh, was etherised, and had a limb amputated by Dr. Duncan, "without the infliction of any pain." Experiments were then made in the London and provincial hospitals; evidence of success accumulated in America and Great Britain; and at length the two great Paris surgeons, Velpeau and Roux, averred, before the two Academies, that the discovery was "a glorious conquest for humanity."

Thus a new era was inaugurated in the science of surgery, both for operators and patients. A month after the first application of ether in England, Dr. Simpson, of Edinburgh, discovered that by its instrumentality the ordinary pains of maternity might be averted without danger. The remedy was used also with a greater or less degree of success in some of the most fearful and painful diseases, and by its aid many persons were rescued from certain death who must otherwise have undergone a difficult, painful, and most dangerous operation.

Ether, the first agent employed in this great revolution, is said to have been known to Raymond Lully and Basil Valentine, the alchemists. In 1540, Valerius Cordus described the method of making it,—the *Oleum Vitrioli dulce*, as he termed it. It consists of 4 atoms of carbon, 5 of hydrogen, and 1 of oxygen. It is usually procured by distilling common alcohol (the hydrated oxide of ethyle) with sulphuric acid: hence its usual name of sulphuric ether; its present chemical name is oxide of ethyle.

Ether was noticed as early as 1540 by pharmaceutical Chemists. Dr. Frobenius and Mr. Godfrey made several experiments on it before the Royal Society, as described in the *Philosophical Transactions* for 1730, when the term *Ether* was first adopted. Mr. Godfrey states, "that this liquor *Æthereus* was formerly very much esteemed and inquired into, doth clearly appear by an experiment I made formerly for my worthy Master Esquire Boyle, by the means of a metallick solution, namely, by the solution of crude mercury united with the *Phlogiston Vini*, or other vegetables; and this æther swam on the top of the solution, which I separated *per Tritorium*. This is what I have done formerly in Esquire Boyle's laboratory; and Sir Isaac Newton was very well acquainted with it too, which, by reason of shortness of life, was not brought to a full end, to do it so readily in quantity." Dr. Frobenius, after describing various experiments, says: "*Æther*, then, is certainly the most noble, efficacious, and useful instrument in all Chy-

mistry and Pharmacy ; *Ubi enim ignis potentialis, ibi actuali non opus est*, inasmuch as essences and essential oils are extracted by it immediately, without so much as the mediation of fire, from woods, barks, roots, herbs, flowers, berries, seeds, &c., from animals, and their parts too."

Morton, the discoverer of etherisation, fell into poverty ; but his partner Jackson claimed the whole merit. Chloroform quickly superseded ether, and Morton, who had, contrary to the usages of the profession, patented his discovery, found his patent valueless.

Another labourer in the field must be mentioned here. In 1846, news of the discovery reached England, when Dr. Snow, who had previously made numerous experiments in respiration and asphyxia, brought the administration of this new agent to great perfection. The ether practice of London went almost exclusively to him. He published a work embodying the whole of his experiences in etherisation ; it was appreciated by the profession, and was selling largely, when the discovery of the application of chloroform threw ether into the shade and the book with it. Dr. Snow was soon satisfied of the greater practicability of chloroform : he at once commenced its use. He next began, in 1856, to experiment with amylene, first upon animals, and if these promised favourably, then upon man. Amylene did not answer his expectations, and he discontinued its use. He died convinced that, though he did not succeed in the object, an anæsthetic will ultimately be discovered which may be inhaled with absolute safety, and which will destroy common sensation without destroying consciousness.

In March 1847 M. Flourens caused animals to inhale pure chloroform, which rendered them insensible ; but believing it to be a dangerous agent, he did not think of commending it for the prevention of human pain. Dr. Chapman says :

Anæsthetic agents should only be administered by those who possess knowledge and experience of their properties. The very essence of anæsthesia consists of a partial arrest of the vital processes, and is, in fact, a stage on the way from life to death : only those agents which are capable of leading us along this solemn path, and which, having done so for a certain distance, will allow us to retrace our steps, are really endued with the power of saving us from pain.

The mixture improperly called Chloric Ether is simply a solution of chloroform in alcohol. Early in 1847, the late Mr. Jacob Bell demonstrated the anæsthetic power of this mixture ; but it was Dr. Simpson, who, upon the suggestion of Mr. Waldie, of the Apothecaries' Hall of Liverpool, first tried chloroform undiluted, discovered the effects of its vapour, and there bound his name indissolubly with the greatest benefit ever conferred on man.

Chloroform was first obtained in 1831, by Guthrie, an American chemist, by distillation of chloride of lime and alcohol.

In 1834, it was examined by Dumas, who showed its real composition to be two atoms of carbon, one of hydrogen, and three of chlorine. From the red ant (*Formica rufa*) is obtained formic acid, consisting of two atoms of carbon, one of hydrogen, and three of oxygen (C_2, H_2O_3). The elements C_2, H , are viewed as a hypothetical radical called *formyle*, which, being united with three equivalents of oxygen, forms the *ter-oxide of formyle*, or *formic*, or *formic acid*. Now, if for the three equivalents of oxygen three equivalents of chlorine were substituted, the product would be a *ter-chloride of formyle*. Such being Dumas's ingenious view of the constitution of this important substance, he very appropriately named it *Chloroform*.

Pure chloroform has a strong, fragrant, ethereal, apple-like odour, and a sweet penetrating taste. It freely dissolves sulphur, phosphorus, iodine, camphor, fats, wax, resins, and caoutchouc. No other liquid is so perfect a solvent of the latter substance, which is left unaltered by it on evaporation.—*Westminster Review*, Jan. 1859.

Thus has the practicability of surgical anæsthesia been established: its safety and expediency in women during childbirth are, however, much controverted.* It was at first supposed to be safer than ether, and was in many instances used with great recklessness, till the first death from chloroform occurred, near Newcastle, in January 1848.

Dr. Snow took notes of between three and four thousand cases in which he had administered chloroform himself. It has been used extensively in every hospital in Europe. It was the greatest boon to our poor wounded in the Crimea and India. The exhaustion of the stock of Chloroform in Lucknow is recorded at one of the greatest calamities in that fearful siege. No fatal case occurred from its frequent use in the Crimea. Dr. Snow could ascertain but fifty fatal cases throughout the world which could fairly be attributed to chloroform during ten years. For several years before his death he made about a thousand a year in fees for administering chloroform in private practice. He met with but one fatal case among the many thousands to whom he administered chloroform. The fatal effect is by paralysing the heart; but the chance of this result, with due care, is very small indeed: it has been compared with the chance of a fatal railway accident.

The effects of chloroform vapour on the Sensitive Plant are very striking; and it has been used to render Bees quiet and innocuous, and while in this state the honey is taken from them; in swarming, they have also been rendered manageable by chloroform.

* See the elaborate paper from the *Westminster Review*, by Dr. Chapman, reprinted in a separate form. Williams and Norgate.

Appendix.

MERCURY, OR QUICKSILVER.*

THIS very remarkable metal, which possesses the singular property of being fluid at common temperatures, was known to the ancients. It often occurs in the native state. Its colour is similar to that of silver; hence the name *hydrargyrum*, from two Greek words signifying "water silver," and *argentum vivum*, quick or living silver; the term "vivum" signifying *quick*, an old Saxon word usually understood in that sense in Scriptural phraseology. Hence, also, the name of Mercury, given by the Alchemists. Quicksilver mines occur in comparatively few places: those of Almaden in Spain, and Idria in Carniola, are best known. Hungary and Transylvania also yield mercury: it has long been obtained in China and Japan and Peru; and recently it has been discovered in great abundance and in remarkable purity in California and Australia. The Chinese from their mercury produce the best vermilion; and both China and Japan are noted for their mirrors.

Mercury occasionally occurs in native globules in the sulphide, cinnabar, or vermilion; which Pliny states Callias, an Athenian, discovered the preparation of (B.C. 505). He also mentions the mines of Almaden, then producing 10,000 Roman pounds annually, though the supply was purposely limited. In 1833, these mines furnished annually nearly 2,244,000 lbs., employed 700 workmen underground, and 200 extracting the metal from the ore at the surface.

Formerly mercury was imported tied up in fresh sheep-skins, and packed in barrels; it is now brought in hammered iron bottles. When pure, its surface makes an excellent mirror: common glasses are coated with mercury spread upon tin-foil, with which it forms a solid amalgam. Mercury dissolves in this manner gold, silver, lead, and other metals; hence its use in extracting them from the ore. The amalgam of silver and copper is used for stopping hollow teeth. Mercury is extensively employed in medicine, as the subchloride, or calomel; triturated with chalk or magnesia, or confection of roses, it forms blue-pill; and the bichloride is corrosive sublimate.

* This, and the three subsequent articles on Mercury, should have appeared in the section on "the Chemistry of Metals," pp. 102-127.

Mercury has long been used in medicine; but the opinion of the necessity for giving it in any quantity is now altogether exploded.

Pure mercury boils at 680° ; its vapour is elastic, like that of water. Geoffroy, at the request of an alchemist, enclosed a quantity of mercury in a strong iron globe, secured by iron hoops, and put the globe into a furnace. Soon after it had acquired a red heat, it burst with great violence, and the mercury was completely dissipated.

Mercury is used in the thermometer as a measurer of temperature. Its boiling-point, as measured by its own expansion, is 680° , but by the expansion of air 662° . If a common thermometer be plunged into boiling mercury, it stands (according to Crichton) at 660° , so that the expansion of the glass is equivalent to 20° ; and almost exactly counteracts the increase of the rate of expansion of the mercury. "The consequence," as Dr. Thomson says, "of this fortunate coincidence is, that an accurately graduated mercurial glass thermometer is an accurate measurer of the increase of temperature as high as the boiling-point of mercury, or to 662° ." The effect of "the mercurial atmosphere" will be found described by Faraday at page 76. Several washes and other preparations of mercury were formerly employed as cosmetics; the making of which was a great source of gain to the empirical chemist, which practice has lasted to our day. Mercury has also been applied to the correction of errors of levelling. Thus, Professor Mitchell, of the United States, has a mode by which, through the means of cups of mercury placed on each pier of the transit instrument, connected by a tube of mercury, he can at each moment of observation determine the level-error of the axis of his transit.

THE FREEZING OF MERCURY.

The congelation of mercury was first effected by M. Braun, of St. Petersburg. On Dec. 14, 1759, the temperature of the air being 34° , M. Braun prepared a freezing mixture of nitrous acid and pounded ice, into which a thermometer being placed, sank to -69° . Then substituting snow for ice, he sank the thermometer to -100° , -244° , and finally to 350° . The mercury in the thermometer was then found to be fixed, and it remained so for more than twelve minutes: on employing a thermometer graduated only to 220° , the mercury collected in the bulb, and remained solid as before. On Dec. 25, M. Braun repeated his experiments: as soon as the mercury became fixed, he broke the bulb of the thermometer, and obtained the mercury in the form of a solid, shining, metallic mass, perfectly malleable, not quite so hard as lead, and to be cut with a knife.

The upper surface of the frozen lump of mercury was concave, and pieces of it sank in fluid mercury, indicating its great contraction.

These philosophers did not, however, determine the freezing-point of mercury, which was proved by a series of admirable experiments performed in Hudson's Bay, with instruments furnished by Mr. Cavendish.

These instruments consisted of a glass cylinder, partially filled with mercury, in which the bulb of a thermometer was placed so as not to touch the side of the vessel; this apparatus was surrounded by a mixture of snow and nitrous acid, when the mercury descended to $38^{\circ}66'$, where it remained stationary, showing this to be the *freezing-point of mercury*.

Mr. Cavendish subsequently showed that mercury in the act of freezing contracts nearly $\frac{1}{23}$ of its whole bulk.—*Abridged from Tomlinson's Student's Manual of Natural Philosophy.*

THE QUICKSILVER MINES OF CALIFORNIA.

The mercury mines of Upper California are only exceeded in value by the gold diggings. Rocks and mountains entirely of cinnabar have been found, and the apparatus for obtaining the pure metal is as simple as that used 1800 years ago: at a common lime-kiln or blast-furnace, 2000 pounds of metal are said to be manufactured daily, and the average yield of metal 50 per cent. California itself affords a good market, large quantities of mercury being used in separating fine particles of gold from the sand and dirt, and which cannot be procured by washing. The aborigines are said to have known and resorted to these cinnabar deposits for centuries to procure colouring materials.

The richest mines, at New Almaden, have yielded from 29 to 72 per cent; and ten furnaces, very defective in operation, have produced from 30,000 to 35,000 lbs. of mercury weekly.

FULMINATING MERCURY.

This fulminate, which is less dangerous and violent than Fulminating Silver, is in great demand as an ingredient in the charge of *percussion-caps* now so generally adopted in gun-locks.

Fulminating Mercury was discovered in 1810 by the Hon. Edward Charles Howard. It is obtained from a solution of mercury in nitric acid mixed with alcohol.

When fulminating mercury is heated to between 300° and 400° , it explodes with a bright flame and much violence; and if substituted for gun-powder, its combustion is so rapid and sudden that, like other detonators of the same class, it bursts the gun without expelling the ball. But it also explodes by percussion and friction, and a little heap of it placed upon an anvil and sharply struck by a hammer, goes off with a deafening

noise. Many hundredweights of this dangerous article are annually manufactured ; it requires great care both in its production and transport.—*Brande's Lectures*, by Scoffern.

Frightful accidents have occurred in the preparation of this compound. On June 4, 1842, Mr. H. Hennell, the principal chemical operator to the Apothecaries' Company, met a terrific death in the laboratory-yard, by the explosion of between five and six pounds of fulminating mercury, which he was manufacturing for the East India Company.

WHAT IS CHAOS ?

Chaos is that confusion in which matter lay when newly produced out of nothing at the beginning of the world, before God, by his almighty word, had put it into the order and condition which it assumed after the six days' creation. Chaos is represented by the ancients as the first principle, ovum, or seed, of nature and the world. All the sophists, sages, naturalists, philosophers, theologues, and poets, held that Chaos was the eldest and first principle, τὸ ἀρχαῖον χάος. The Barbarians, Phœnicians, Egyptians, Persians, and many other nations, all refer the origin of the world to a rude, mixed, confused mass of matter. The Greeks—Orpheus, Hesiod, Menander, Aristophanes, Euripides, and the writers of the Cyclic Poems—all speak of the first Chaos ; while the Ionic and Platonic philosophers built the world out of it. The Stoics held, that as the world was first made of a Chaos, it shall at last be reduced to a Chaos ; and that its periods and revolutions in the mean time are only transitions from one Chaos to another. Lastly, the Latins, as Ennius, Varro, Ovid, Lucretius, Statius, &c., were all of the same opinion. Nor is there any sect or nation whatsoever that does not derive their διακόσμησις, *the structure of the world*, from a Chaos.

The opinion first arose among the Barbarians, from whom it spread to the Greeks, and from the Greeks to the Romans and other nations. Dr. Burnet observes, that besides Aristotle and a few pseudo-Pythagoreans, nobody ever asserted that our world was always from eternity of the same nature, form, and structure, as at present ; but that it had been the standing opinion of the wise men of all ages, that what we now call the *earth* was originally an unformed, indigested mass of heterogeneous matter called *Chaos*, and no more than the rudiments and materials of the present world.

It does not appear who first broached the notion of a Chaos. Moses, the oldest of all writers, derives the origin of this world from a confusion of matter, dark, void, deep, without form, which he calls *tohu boku*, which is precisely the Chaos of the Greek and Barbarian philosophers. Moses goes no farther

than the Chaos, nor tells us whence it took its origin, or whence arose its confused state; and where Moses stops, there precisely do all the rest. Dr. Burnet endeavours to show, that as the ancient philosophers who wrote of the cosmogony acknowledge a Chaos as the principle of the world, so the divines, or writers of the theogony, derive the origin or generation of their fabled gods from the same principle.—*Encycl. Brit.*

THE ARK OF NOAH.

In 1730, Dr. Stukeley wrote: "According to the calculations I have made, I find God Almighty ordered Noah to get the creatures into the Ark on Sunday, the 12th of October, the very day of the autumnal equinox of that year; and on this present day, on the Sunday sennight following (the 19th of October), that terrible catastrophe began, the moon being past her third quarter."

Sir Gardner Wilkinson, in his work *The Egyptians in the Time of the Pharaohs*, in speaking of the Ark, mentions a strange attempt to connect the name of Thebes with the Hebrew word *Thebeh*, and thence with the Ark of Noah; which is at once shown to be erroneous, from the name of that city being a corruption of the Egyptian *Apé*, or with the article *Tâpé* (in the Memphitic dialect *ihâpé*), "the head," or "capital," converted by the Greeks into their own *Thébai*.

PAST AND PRESENT AGE OF PLANTS AND ANIMALS.

From the age of plants and animals in the present day, we are not entitled to infer their age in primitive times. Without appealing to the influence of food, and climate, and soil, on the growth of animal and vegetable bodies, we find the truth of our position in the history of our own species. During the first 2000 years of the human era, the laws of vital organisation were entirely different from what they are in the present day. From Adam to Abraham, the age of man varied from 969 to 175 years, and gradually declined to the average of three score and ten; and, in like manner, the plants and animals of primeval times, when they were required as epochs in the chronology of creation, may have had a more luxuriant growth and a shorter existence.—*Sir David Brewster's "More Worlds than One."*

As regards the last 3000 years, it is not difficult to prove that during this period the usual duration of the life of man has remained the same, as we read in the ninetieth Psalm, "A Prayer of Moses, the man of God," in which it is expressly said that the age of man is 70, and sometimes reaches 80 years.

GREAT AGE OF THE PATRIARCHS.

In May 1858, at a meeting of the Royal Society of Literature, at which the Bishop of St. David's presided, Mr. Poole read a paper "On a Papyrus brought from Egypt some years since by M. Prisse," in which he showed that it was really a much more curious record than had been at first suspected by its discoverer, and that the Rev. Dunbar Heath had been the first scholar who had suggested the true character and value of its contents. Mr. Poole stated that the papyrus was written by a person called Ptah-hotp, the eldest son of the king, and that it is dated in the reign of Assa—about B.C. 1900. The writer addresses his son in a discourse of excellent moral instruction, conveyed in terse and vigorous language. He asserts that he is delivering "traditional wisdom," the "speech of the Past;" and his style is not unlike portions of the Book of Proverbs. It is remarkable that Osiris is the only one of the deities of the land who is directly mentioned, and that the word "God" is often used alone; and it is important to notice, that if, as is generally agreed, Ptah-hotp was the eldest son of the reigning monarch Assa, his father must have lived to the age of not less than 130 years, as Ptah-hotp states his own age at the time he wrote this document was 110 years. We have thus important evidence of the continuance within the historic period of the great age attributed in Holy Scripture to the early patriarchs. Mr. Poole further stated, that this king Assa was supposed to be either a very early Memphite king of the third dynasty, or a shepherd king of the fifteenth dynasty, who also reigned at Memphis: this latter view Mr. Poole himself holds, believing this king to be the same as Manetho's Assis.

THE MANUFACTURE OF IRON.—PP. 110-115.

By Mr. Bessemer's beautiful process, molten iron just from the cupola is converted, without fuel, and literally at a breath, into such steel as could not be made in many weeks upon the old method. The great improvement which we may expect in the manufacture of wrought iron is, in bringing it, by Mr. Bessemer's process, from cast iron directly into a malleable ingot, which may then be heated and afterwards rolled or hammered to any required form. The homogeneous irons, so called, are brought into the same condition by a very much more complicated and wasteful process. Before we can ever depend upon the integrity of large masses of malleable iron, we must be able to bring them at once from the fluid state into a form approximating to that which they are intended finally to have.—*The Engineer*, No. 225.

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